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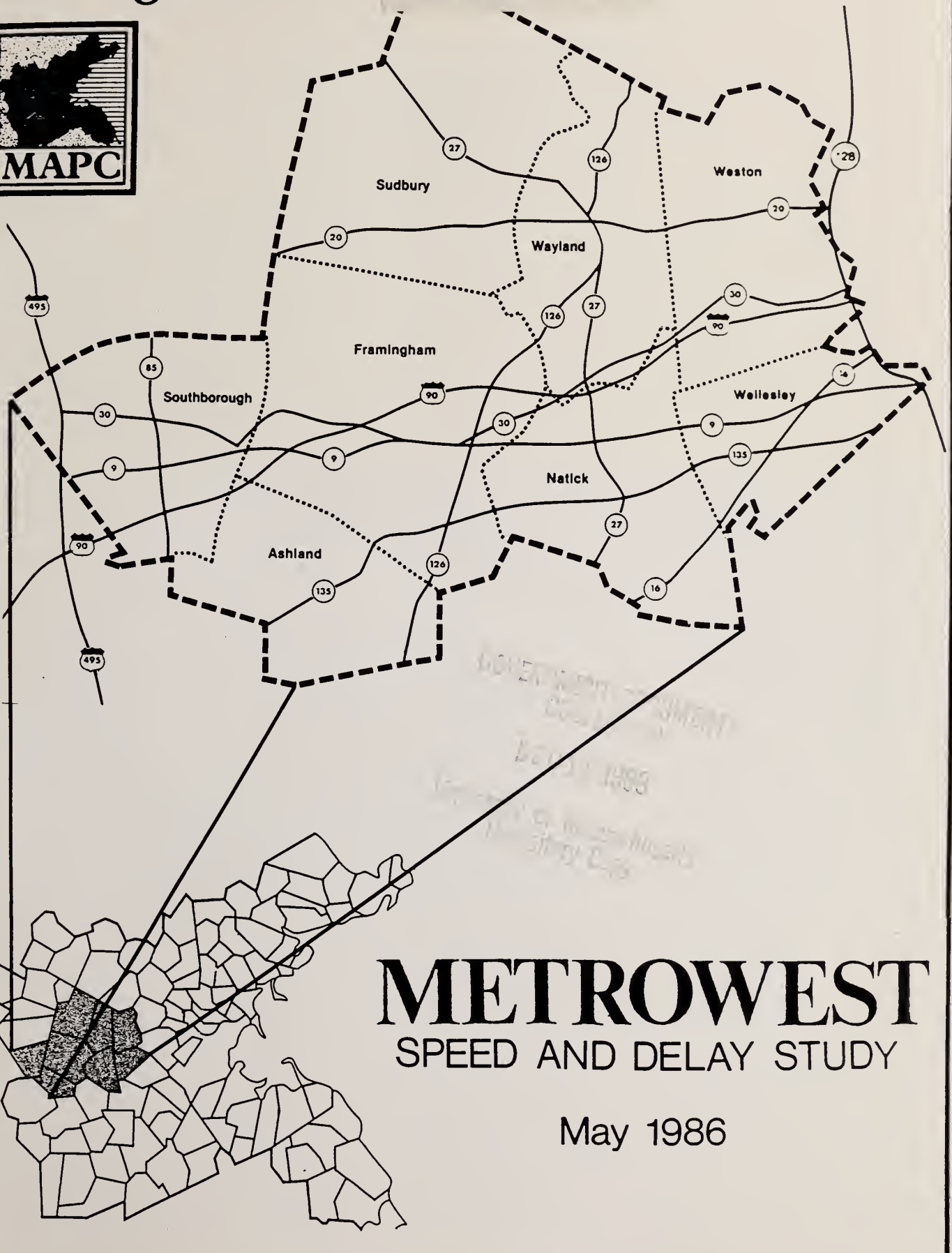

METROWEST

SPEED AND DELAY STUDY

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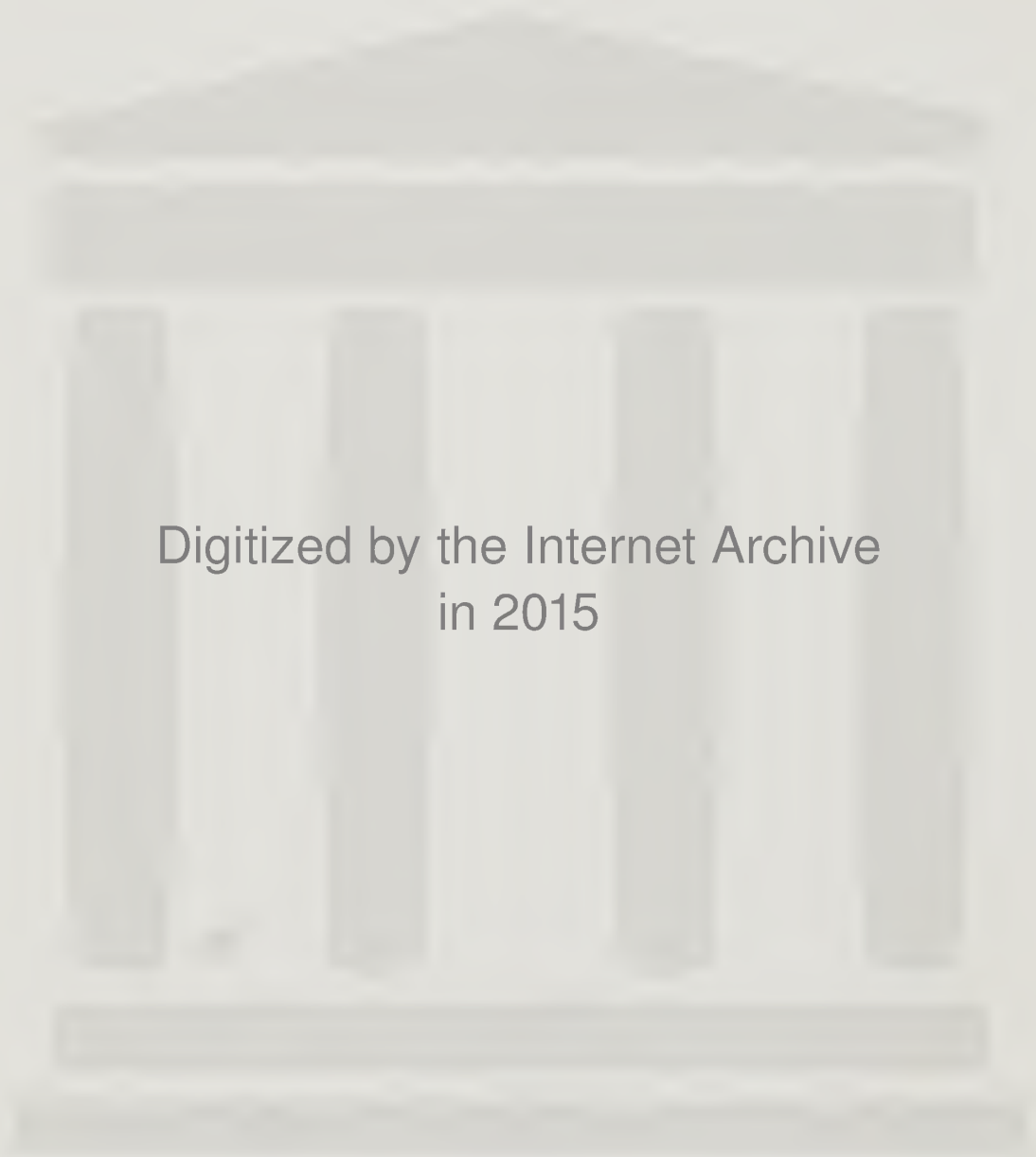
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METROWEST SPEED AND DELAY STUDY
FOR THE METROWEST GROWTH MANAGEMENT COMMITTEE

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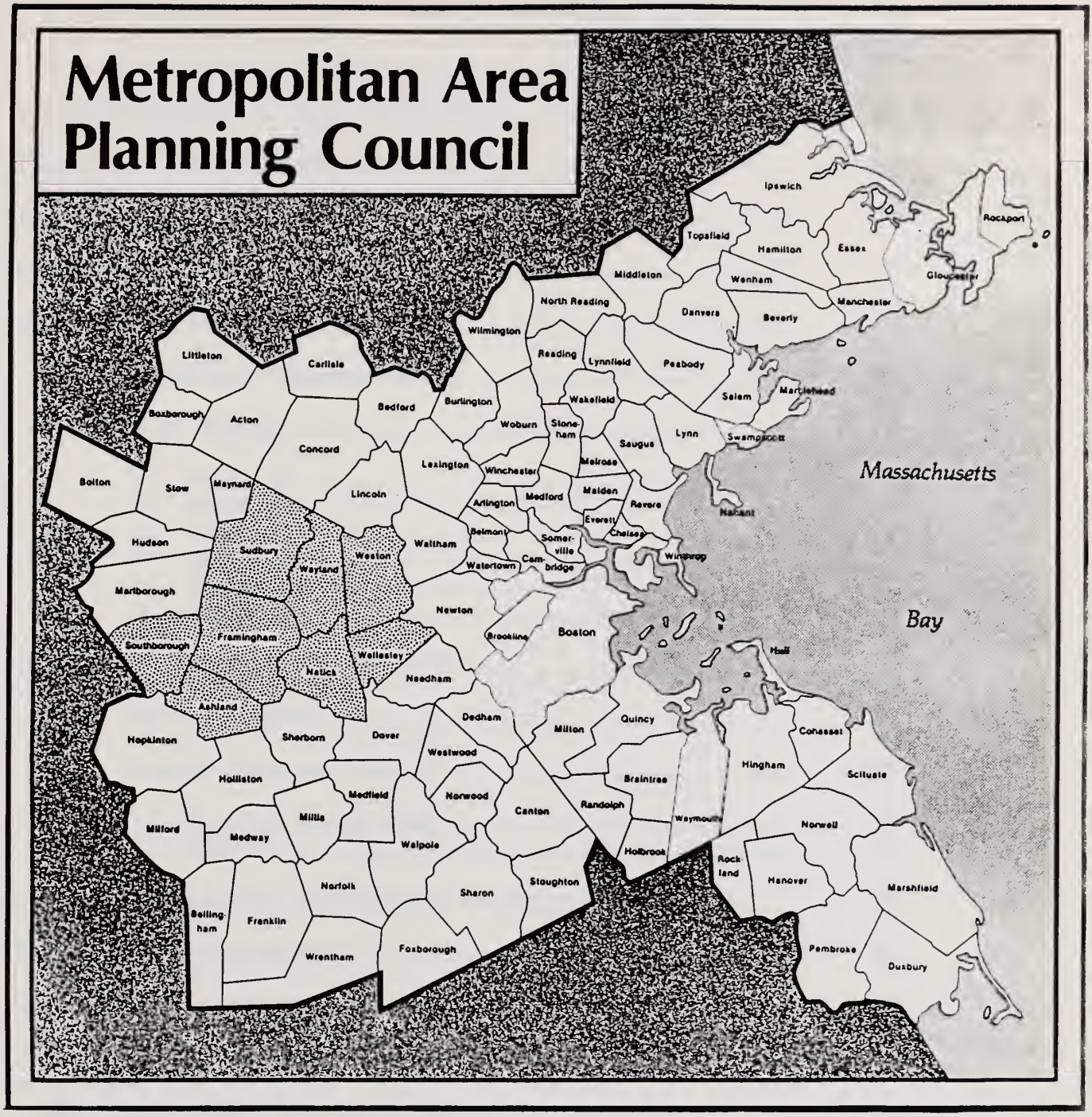
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AREA OF STUDY

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EXECUTIVE SUMMARY

The MetroWest Speed and Delay Study identifies several problem locations that have been studied before. Communities are familiar with these problems, but often do not recognize the relation to problems in other towns. This is the first look from a subregional perspective at commuter travel in these eight towns as a whole system and how it functions.

The objectives of the study are two-fold. The first is to identify where traffic problems occur, their relative severity, and their effect on the region as a whole. The second objective is to inventory the location and status of projects for improving traffic conditions in the area. These objectives were designed to give the MetroWest Growth Management Committee a "snap-shot" picture in time of where commuter problems are, as well as the status of improvements "in the pipeline". It also points out the missing pieces - what needs to be studied, what has not been looked at yet at all (or not recently), and what planned projects need to be expedited.

Average speeds and delays for 223 miles of roadway including 175 intersections were studied. The routes were chosen for study based on the towns' perceptions of where problems are. They include most of the region's mileage on the federal-aid system. For purposes of statistical reliability, ideally, 16 test runs would be made on each segment studied - four (4) in each direction, both in the morning and afternoon peak periods (from 7-9 a.m. and 4-6 p.m. respectively). Over 70% of the driving was by volunteers and town employees with the remainder by MAPC staff, for a total of nearly 2500 miles.

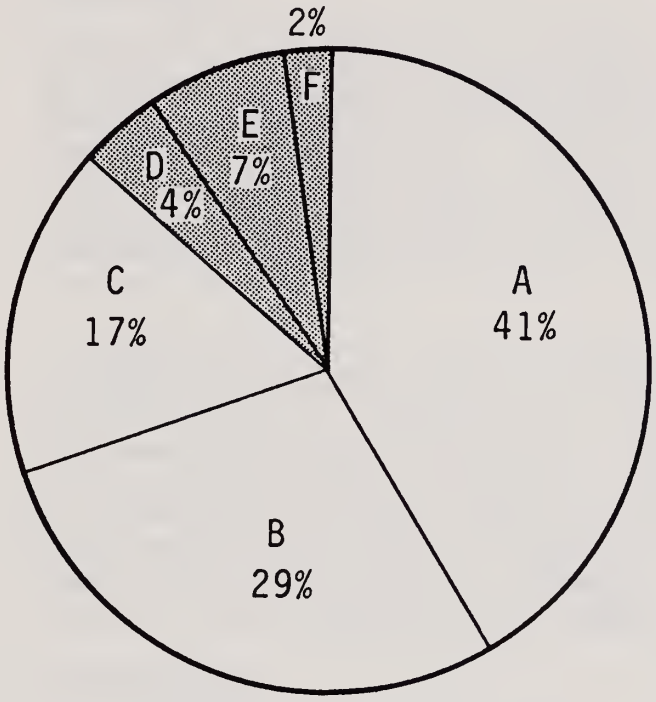
As a means for evaluating the operations of the roadways and intersections studied, Levels of Service (LOS) were established based on criteria set forth by the Institute of Transportation Engineers (ITE). Roadway segments with average speeds of 18.0 mph are defined to be deficient, as are intersections with an average delay of 25 seconds or longer.

A "snapshot" picture of the overall regional roadway for the afternoon peak period is found in Figure 1. The number of miles in each of the Level of Service (LOS) categories is displayed as a percentage of the total number of miles studied and similarly, the number of intersections. As can be seen, when the highway system is looked at in terms of highway miles, only 22.4 miles or 13% of those studied are found deficient. However, 60 intersections or 44% are deficient. This indicates that the major operational problems in MetroWest are a function of capacity at intersections (ability of intersections to handle traffic) and not the capacity of the stretches of roadway between intersections. Generally, those roadway segments that are found to be deficient are those that approach deficient intersections.

The inventory of traffic improvements in progress revealed that 32 of 42 existing projects address problem intersections. But while there are 74 intersections defined to be deficient in the AM and/or PM, less than half of these intersections have been studied for future improvements. (Note: 60 of these are deficient in the PM only). Four of the seven worst intersections found in the region (those having two or more approaches operating at LOS F) did not have approved projects in place.

METROWEST SPEED AND DELAY

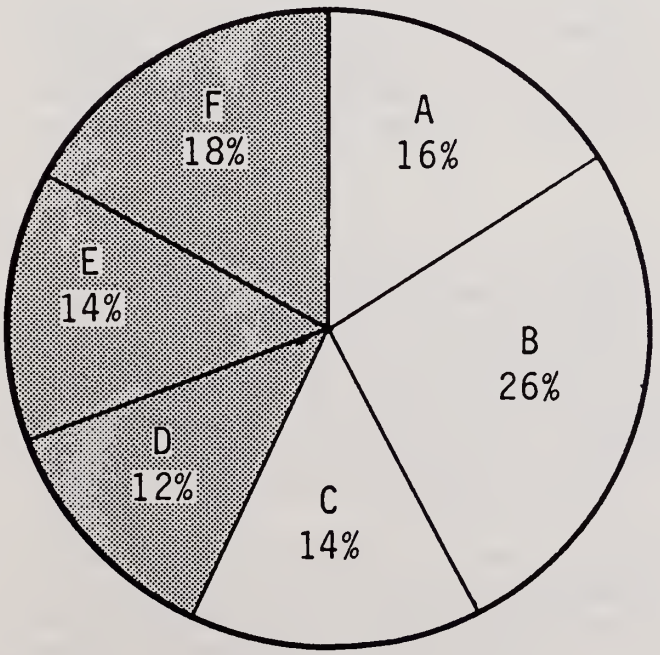
Figure 1 - LEVELS OF SERVICE (LOS) ON HIGHWAY SEGMENTS AND AT INTERSECTIONS AS A PERCENT OF TOTAL, FOR PM PEAK PERIOD.



Highway Segments
Total miles = 183

LOS	Average Speed (mph)
A	≥ 30
B	≥ 24
C	≥ 18
D	≥ 14
E	≥ 10
F	< 10

▒ Deficient - defined as LOS D, E or F



Intersections
Total = 135

LOS	Average Delay (sec)
A	< 5
B	5 - 14
C	15 - 24
D	25 - 39
E	40 - 60
F	> 60

MAY 1986

In conclusion, the committee can use the information in this study to identify the traffic "hot spots" of the subregion. In addition to traffic speeds and delays addressed in this study, future project selection must also include an accident analysis.

I. INTRODUCTION

Recognizing that most growth-related problems do not stop at town boundaries, the communities that make up the MetroWest Growth Impacts Study decided to work together to study and address growth problems at a regional level. Out of this concern, the MetroWest Growth Management Committee was established, comprised of a selectman and planning board member from each of the eight communities to study problems and implement recommendations from a regional perspective.

The objectives of this traffic study are to develop a region-wide perspective on traffic congestion by identifying problem locations and their relative severity and to inventory work to date toward improvements at problem locations. Several projects are found to be on the Transportation Improvement Program (TIP), a prerequisite for the expenditure of federal funds. The questions arise "Why aren't these projects moving?" and "What can be done by the Committee and communities to help move them along?" This study does not include Route 9, which is addressed in a separate effort by CTPS (1).

II. DATA COLLECTED

The routes for which data on average speeds and delays was collected for the morning and evening peak periods, are shown on Map 1 which serves as the base map for the report. All intersections on these routes were studied, as well.

Data was collected for a total of 223 miles of roadway and 175 intersections. All of the information collected is available in the Appendix A of this report, published under separate cover. However, not all of it was valid for use in the study, due to such reasons as not enough test runs made or incomplete entries.

III. STUDY DESIGN

A speed and delay study was conducted to obtain the average speed at which traffic moves along major routes and the average length of delay or stopped-time at intersections. The committee agreed to use volunteers from their communities to do the field work to reduce the overall cost of the study, as well as to encourage citizen participation by members of the community. It was hoped that much information could be gleaned from the driving done by MetroWest commuters in their everyday routine.

A more detailed account of the study design, including route selection process, data collection procedure, validity of data, level of service criteria and use of volunteers, and a list of volunteers is found in Appendices B through G.

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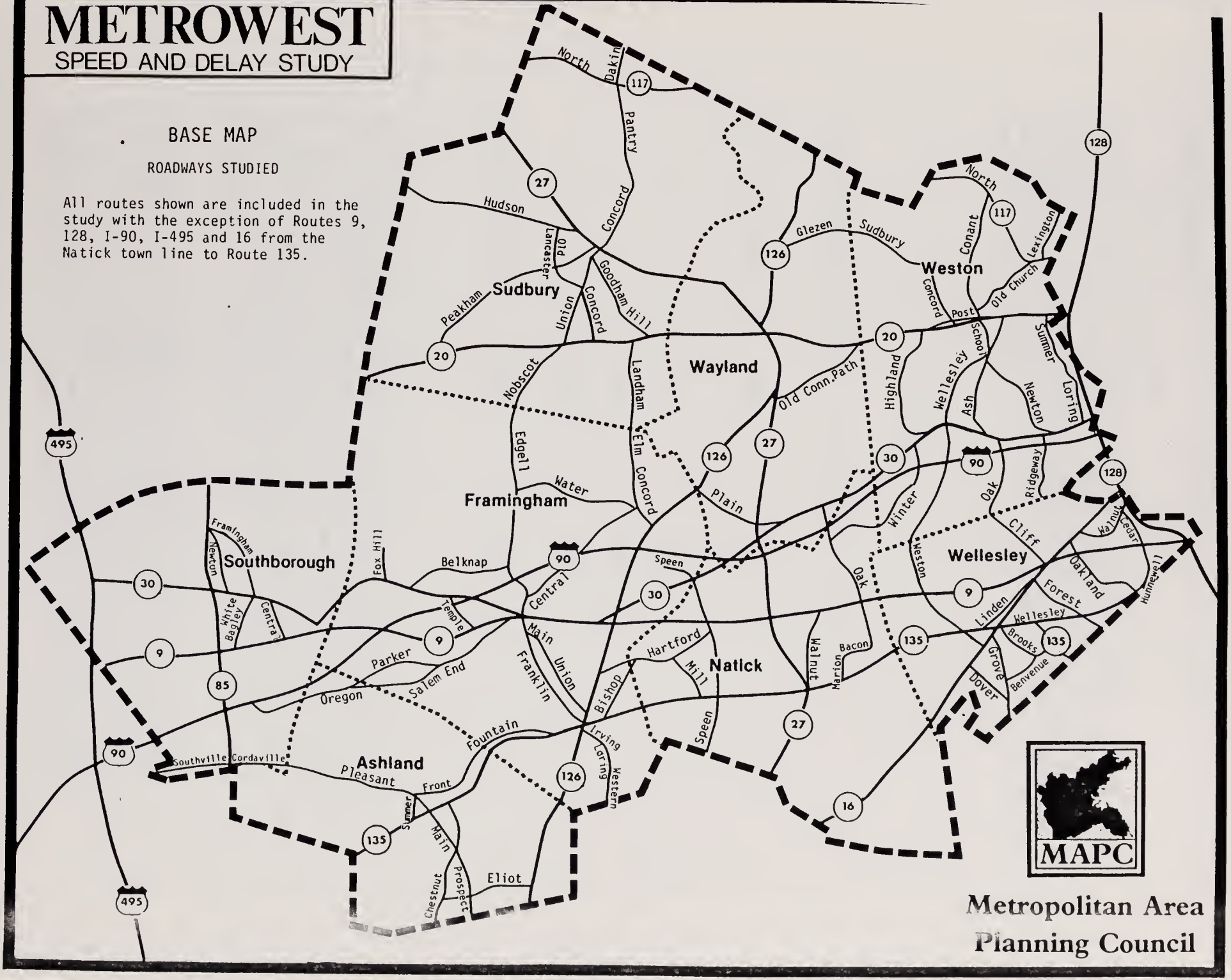
SPEED AND DELAY STUDY



MAP 1

IV. HIGHWAY ANALYSIS

A. Regional Highway System

A regional summary of deficient miles, defined as having a level of service of D, E, or F in one or both directions, is found in Table 1. Speeds are generally slower in the PM peak period, with 2.5 more miles overall in the deficient category. There were nearly twice the number of miles operating at LOS E and F in the afternoon as in the morning peak period.

Table 1

Miles of Highway with Level of Service D, E, or F

Level of Service	AM	PM
D	12.1	8.0
E	5.8	10.6
F	2.0	3.8
Total Deficient	19.9	22.4

Segments of roadway which operate at levels of service (LOS) D, E and F are plotted for AM and PM peak periods respectively on Maps 2 and 3. There are more miles of deficient roadways (as defined by LOS D, E or F) and, as illustrated, for those roads that are deficient in both the morning and afternoon in the PM peak period, they generally show a level of service equal to or worse than the AM peak period. Valid data was collected in one direction only for 8 morning and 4 afternoon segments shown. For further detail see Appendix H.

The slowest travel speeds for both AM and PM peak periods are associated with the towns' central business districts (CBD's). The reasons behind this are two-fold and have to do with higher traffic volumes and higher densities of signalized intersections per mile. Traffic volumes are high at these locations because they serve as major activity centers - where stores and services are found. The most concentrated areas of slow speeds found by this

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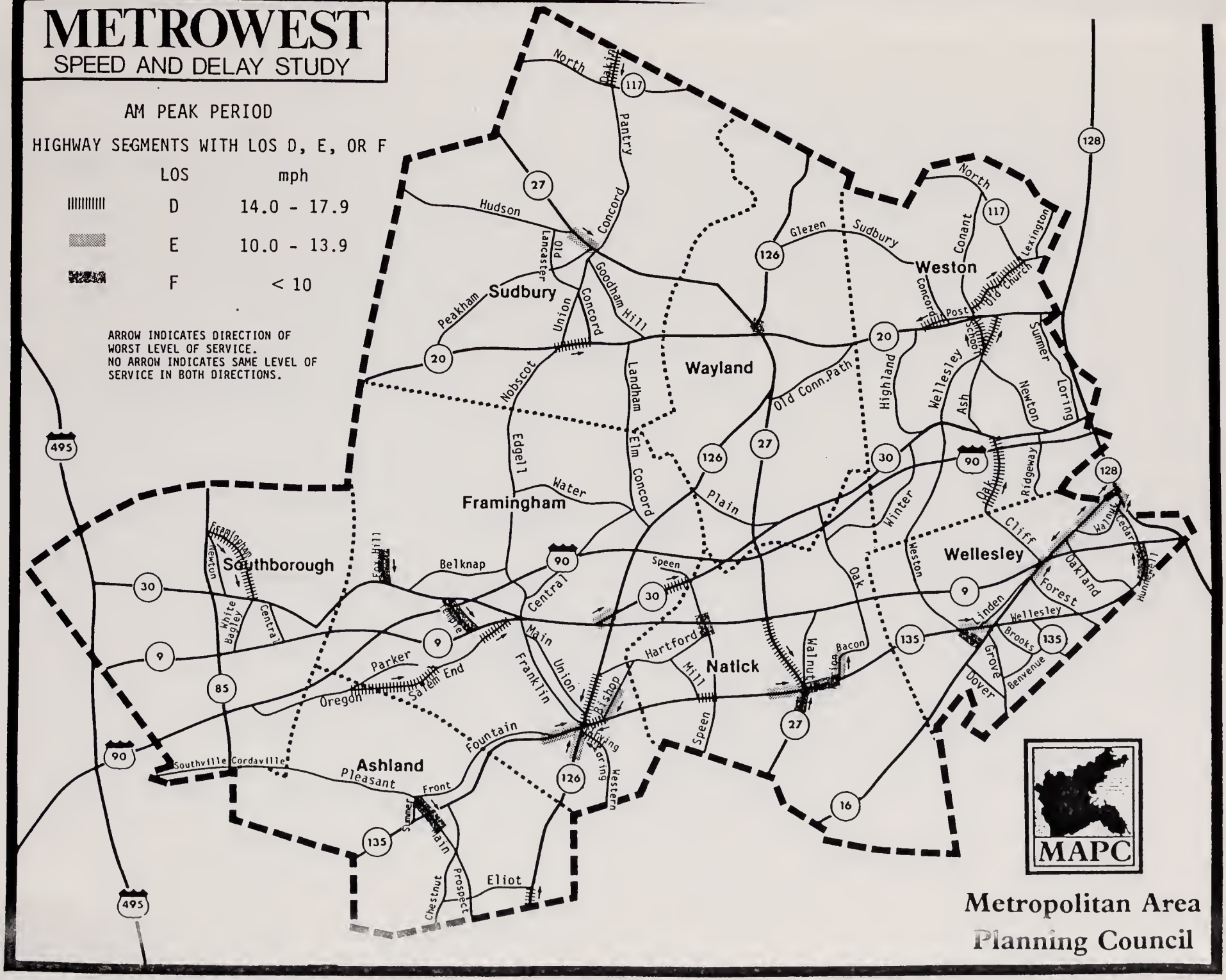
AM PEAK PERIOD

HIGHWAY SEGMENTS WITH LOS D, E, OR F

	LOS	mph
|||	D	14.0 - 17.9
|||	E	10.0 - 13.9
|||	F	< 10

ARROW INDICATES DIRECTION OF WORST LEVEL OF SERVICE.
NO ARROW INDICATES SAME LEVEL OF SERVICE IN BOTH DIRECTIONS.


Sudbury
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Framingham
Weston
Wellesley
Natick
Ashland
Southborough
North
Pantry
Hudson
Concord
Old Lancaster
Peakham
Union
Goodham Hill
Nobscot
Landham
Edgell
Water
Elm
Plain
Old Conn.Path
Highland
Wellesley
Ash
Newton
Loring
Summer
Glezen
Sudbury
Conant
Lexington
Old Church
Post
School
Ridgeway
Oak
Winter
Cliff
Walnut
Cedar
Weston
Forest
Oakland
Hunnewell
Linden
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Benvenue
Grove
Dover
Bacon
Hartford
Mill
Speen
Main
Franklin
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Irving
Western
Central
Belknap
Parker
Salem End
Oregon
Fountain
Pleasant
Front
Eliot
Prospect
Chestnut
Southville
Cordaville
Framingham
Newton
Edgell Hill
White
Bagley
Temple
Walnut
Bacon
Speen
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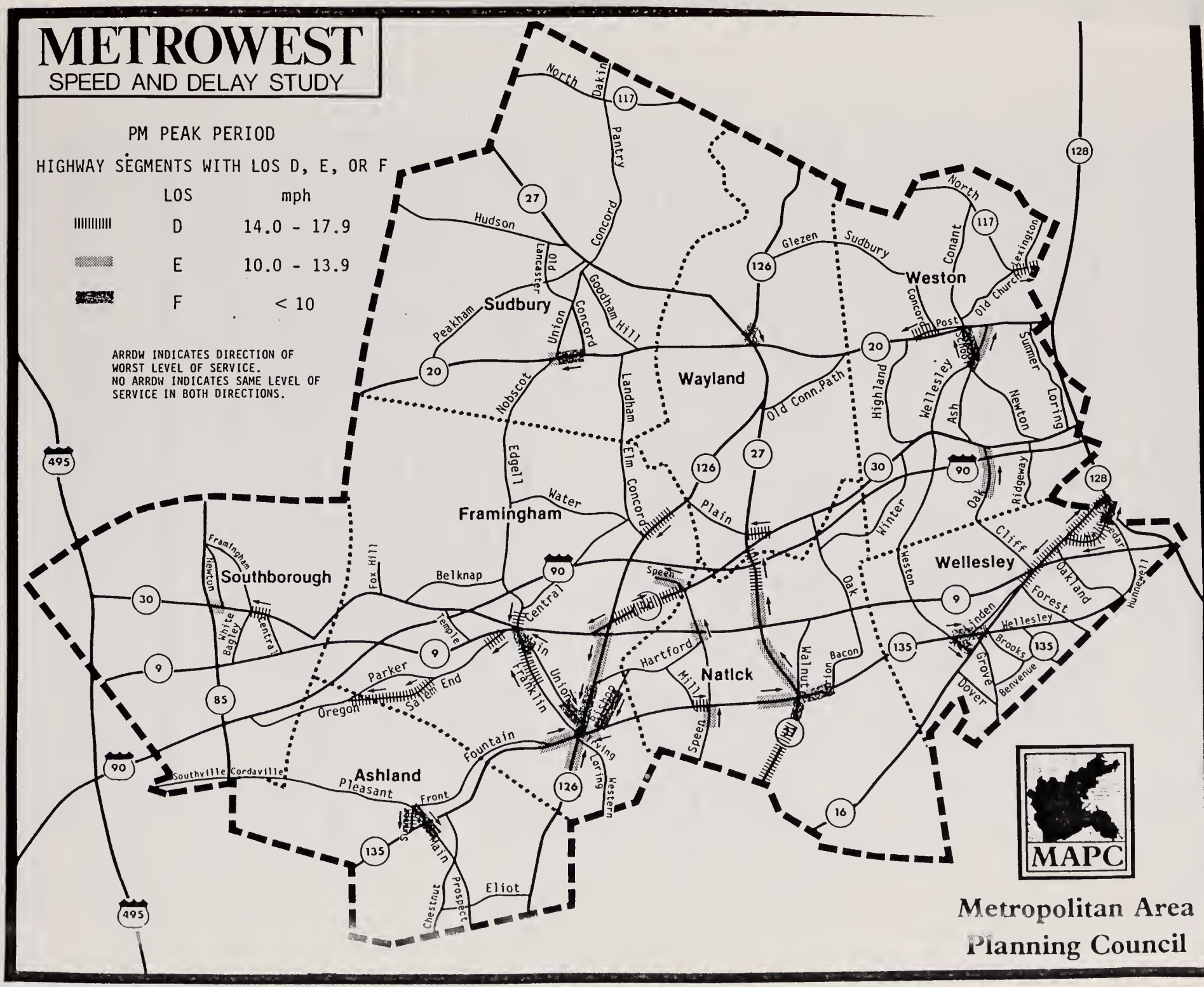

study in both the morning and afternoon peak periods are in the downtown areas of Framingham and Natick where Route 135 is crossed by the north-south Routes 126 and 27 respectively, and met by other town roads in the same vicinities.

Secondly, traffic signals are needed to control the large number of vehicles. Speed is strongly influenced by the number of signals per mile and the average intersection delay. On a given road, such factors as inappropriate signal timing and poor progression of vehicles through the intersection can substantially impede the average speed. The more signals per mile a roadway has, the more it is susceptible to these factors. This condition is evident along Route 16 and Route 135 which show slow speeds in both morning and afternoon peak periods from Weston Road to Route 128. It should be noted that speeds on Route 16 were found to be slower in the morning, contrary to the opposing trend for the region overall.

Segments of roads which meet or cross a heavily traveled major route also show slow speeds because of the long delay time at the intersection of the major route. These delays generally occur where a town road meets a major route, and are particularly lengthy if the intersection is not signalized. Examples are Framingham Road in Southborough and Foxhill Road in Framingham, southbound in the morning peak period, both of which are controlled for access onto heavily traveled Route 30 by stop signs. A similar situation exists in Weston for Oak Street northbound onto Route 30, as well as Post Road, westbound, and Wellesley and School Streets, northbound onto Route 20, for both the morning and afternoon. The maps indicate other examples as well.

B. Analysis of Major Routes

Average travel speeds are diagrammed for morning and afternoon peak periods in both directions for state Routes 16, 20, 27, 30, 126, and 135 in Figures 2 to 7 respectively. Beginning from any point and proceeding in the direction of travel, one can easily see how the average speed rises and falls along the routes. Low points in the graph represent traffic congestion along the segment or in the intersection it is approaching, while high points indicate those sections of the route where traffic proceeds with less delay. The histograms include dotted lines indicating level of service D or less to facilitate identification of those sections of roadway which are congested. It can be seen how congestion along a segment affects the preceding segment, as well as the correlation between the length of a segment and its average speed.

The following sections discuss the travel conditions on the major routes studied.

1. Route 16 (Route 135 <Wellesley> to Route 128 <Wellesley/Newton Line>)

During the morning peak period, Route 16 is heavily congested in both directions from Forest Street to Route 128. It operates at level of service (LOS) D or worse (Figures 2-a and 2-b). The survey

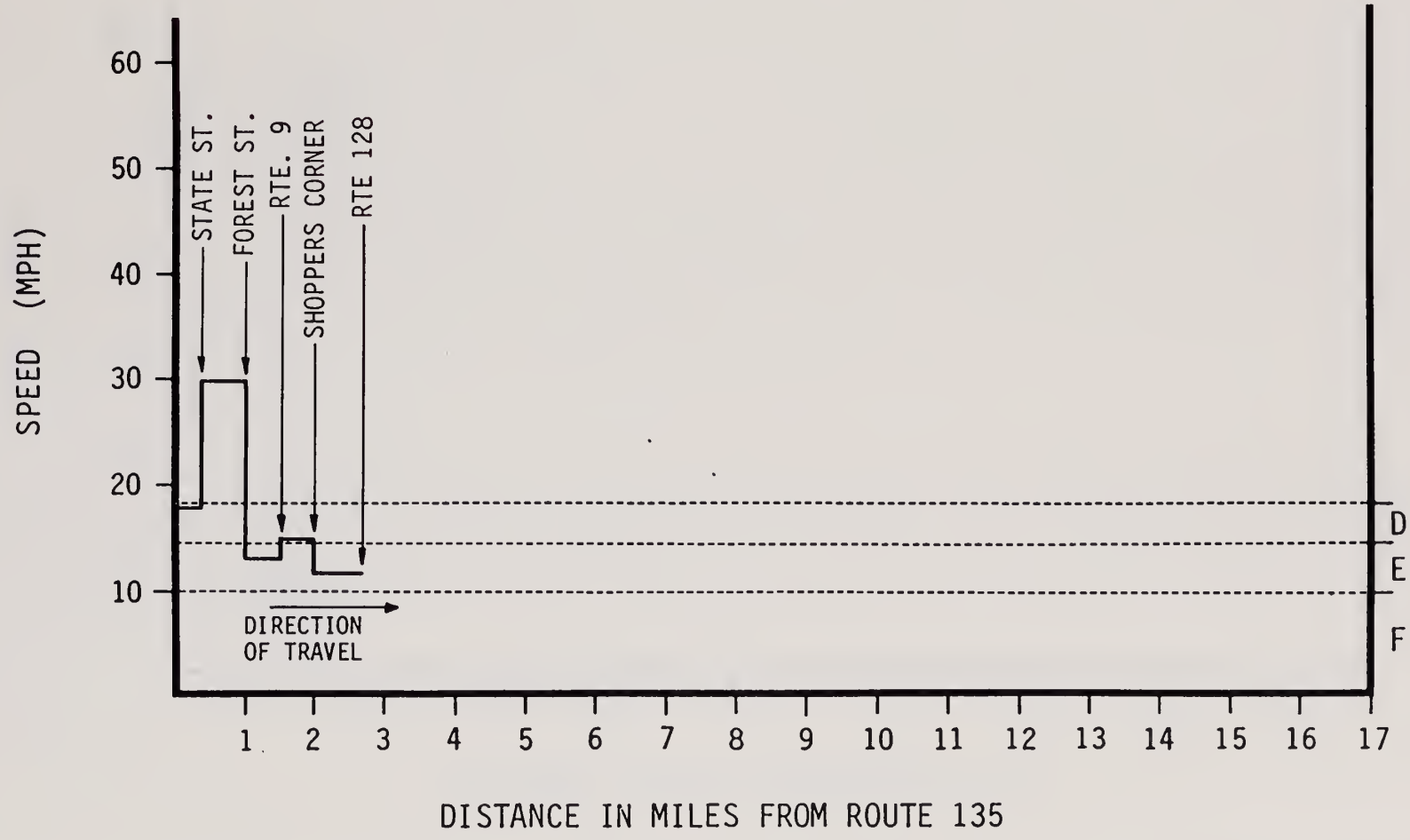

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Fig. 2-a ROUTE 16 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
EASTBOUND

MAPC

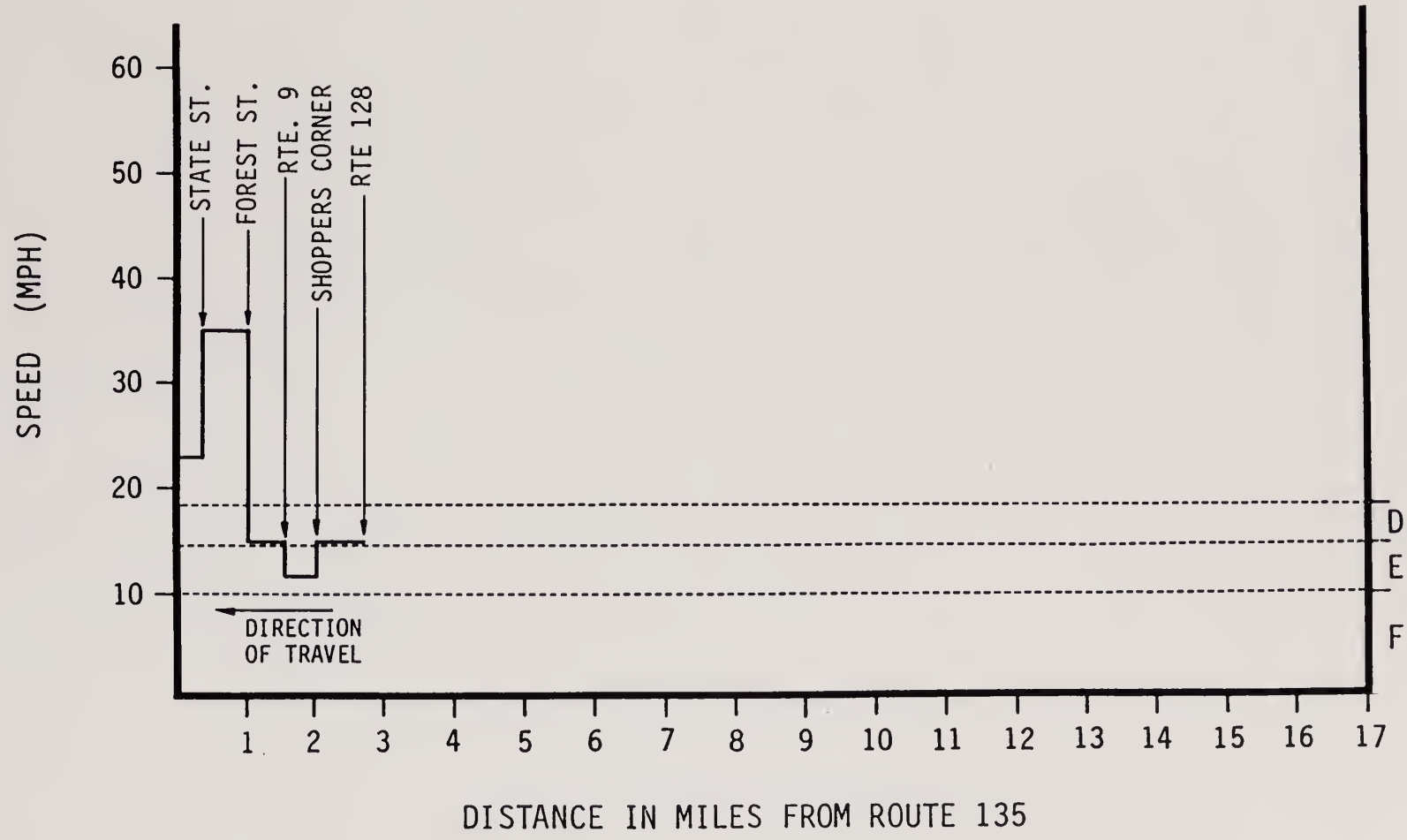

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Fig. 2-b ROUTE 16 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
WESTBOUND

MAPC

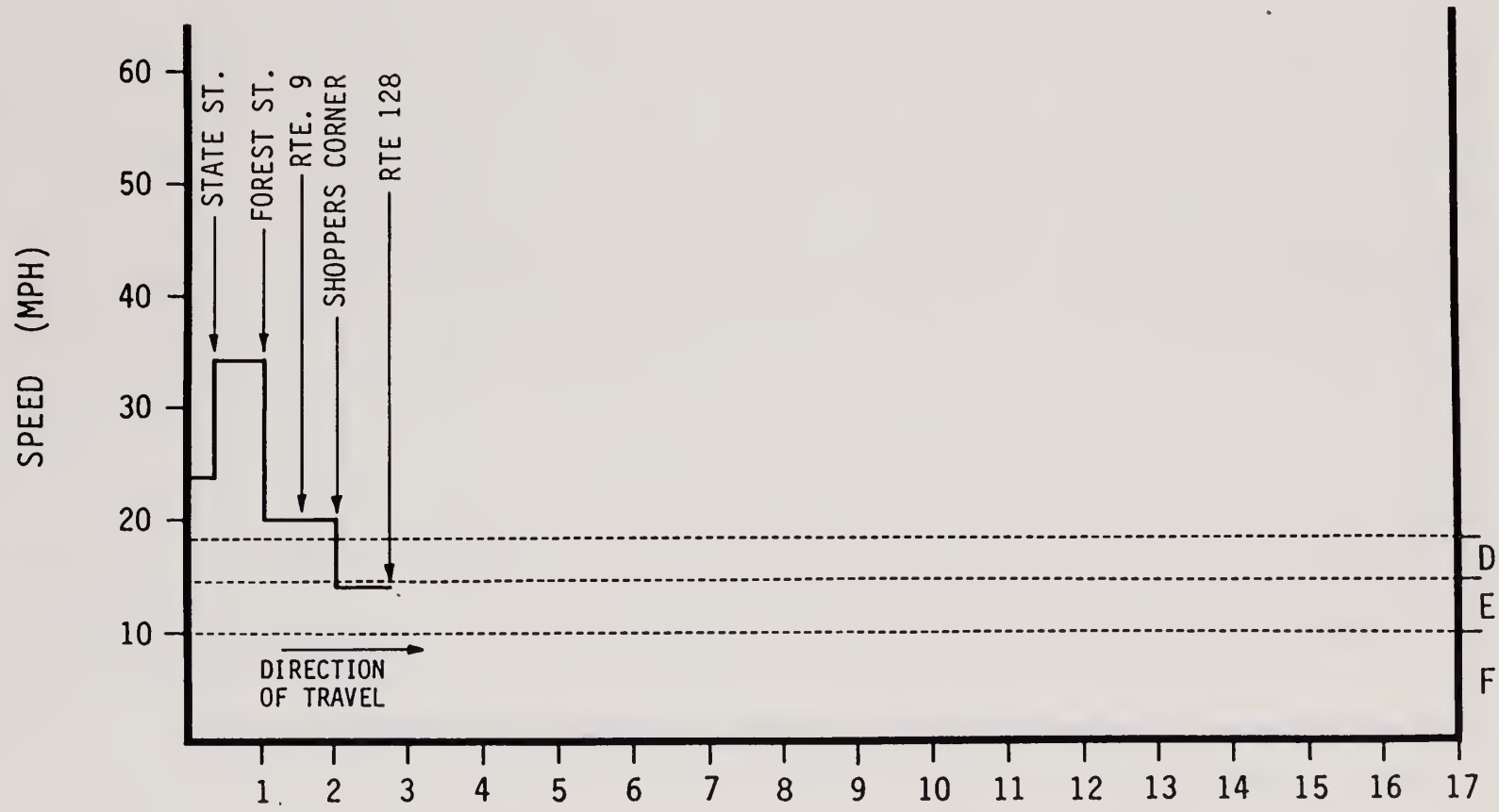

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Fig. 2-c ROUTE 16 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
EASTBOUND

MAPC

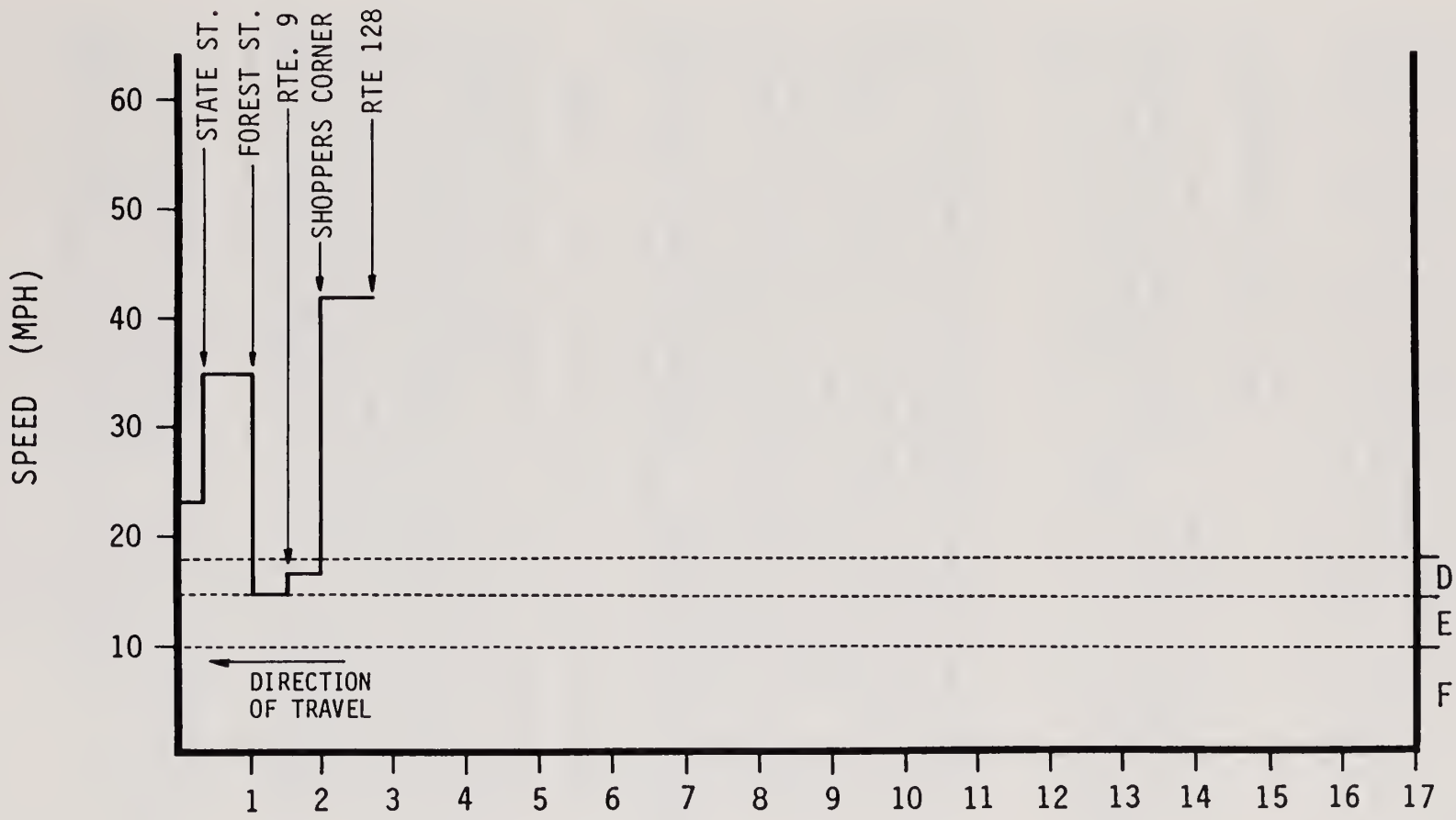

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Fig. 2-d ROUTE 16 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
WESTBOUND

MAPC

shows afternoon traffic between Route 128 and Shoppers' Corner (in the vicinity of the westernmost intersection with Walnut Street in Wellesley) to operate at LOS D in the eastbound direction. The westbound direction operates 28 mph faster -- at 42 mph (Figures 2-c and 2-d). This large difference is due to the fact that the eastbound runs were all made between 5:15 p.m. and 5:30 p.m; the westbound runs all began around 4:00 p.m. because the commuters who surveyed these routes drove them at the same time every day.

2. Route 20 (Sudbury/Marlborough Town Line to Route 128 <Weston/Waltham Town Line>)

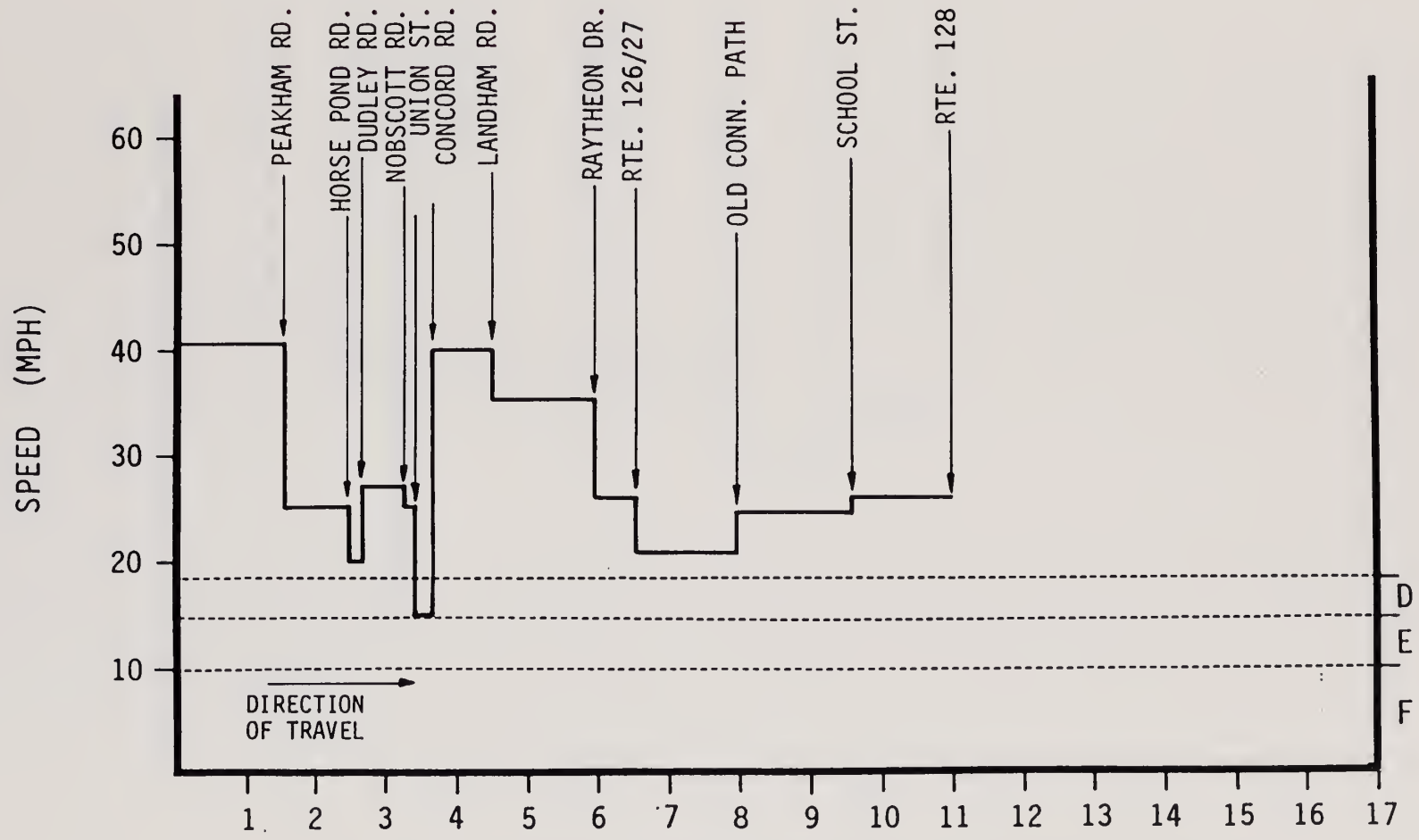
During the morning peak period, speeds are generally over 20 mph eastbound and 30 mph westbound. Traffic in both directions does slow somewhat around the intersections with Nobscot Road, Union Street, and Concord Road in Sudbury, and also as it approaches the intersection of Old Connecticut Path in Wayland (Figures 3-a and 3-b).

As in the morning, most afternoon congestion occurs in the vicinity of the intersections with Nobscot Road, Union Street, and Concord Road. Of these, the approaches to Union Street are the worst (Figures 3-c and 3-d). Westbound traffic in this area is especially slowed. The segment between Concord Road and Union Street functions at less than 10 mph or level of service (LOS) F and the section between Union Street and Nobscot Road at LOS E. Eastbound traffic on Route 20 traveling through Wayland and Weston experiences less delay in the afternoon than in the morning. It slows to level of service D when approaching the junction of Routes 126 and 27 from the Raytheon Plant in Wayland. Afternoon traffic, westbound, from Route 128 to Concord Road in Sudbury averages in excess of 30 mph.

3. Route 27 (West Street <Natick> to Sudbury/Maynard Town Line)

During the morning peak period, Route 27 operates at LOS D or worse in both directions south of Route 9, with severe congestion at its intersection with Route 135 in downtown Natick (Figures 4-a and 4-b). For Route 9 to Route 20 northbound, speeds hover around 25 mph and then jump to an average speed of more than 40 mph north of Route 20. Congestion is obvious in both directions of travel between Hudson Road and Concord Road in Sudbury, where morning southbound traffic operates at LOS D. With this one exception, Route 27 southbound operates at LOS A from the Sudbury/Maynard Town Line to Evergreen Street Line with speeds in excess of 30 mph.

As in the morning, afternoon traffic is slow-moving in downtown Natick, especially southbound. Traffic flows considerably faster in both directions, north of Route 30 (Figures 4-c and 4-d). The segment between Concord Road and Hudson Road is much slower than the adjoining segments, as it is in the morning.



Source: Vanasse-Hangen

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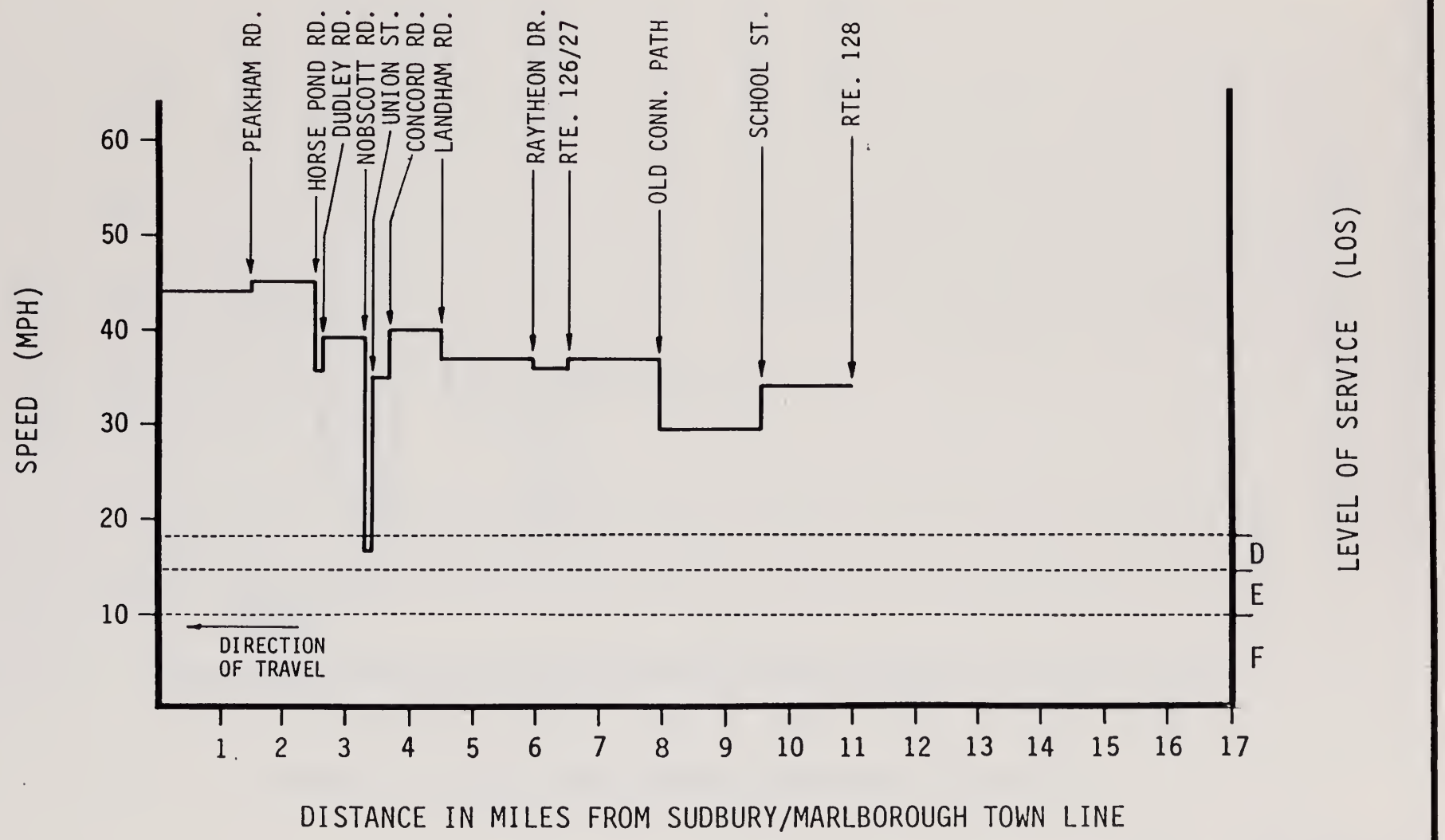
Fig. 3-a ROUTE 20 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
EASTBOUND

MAPC



Source: Vanasse-Hangen

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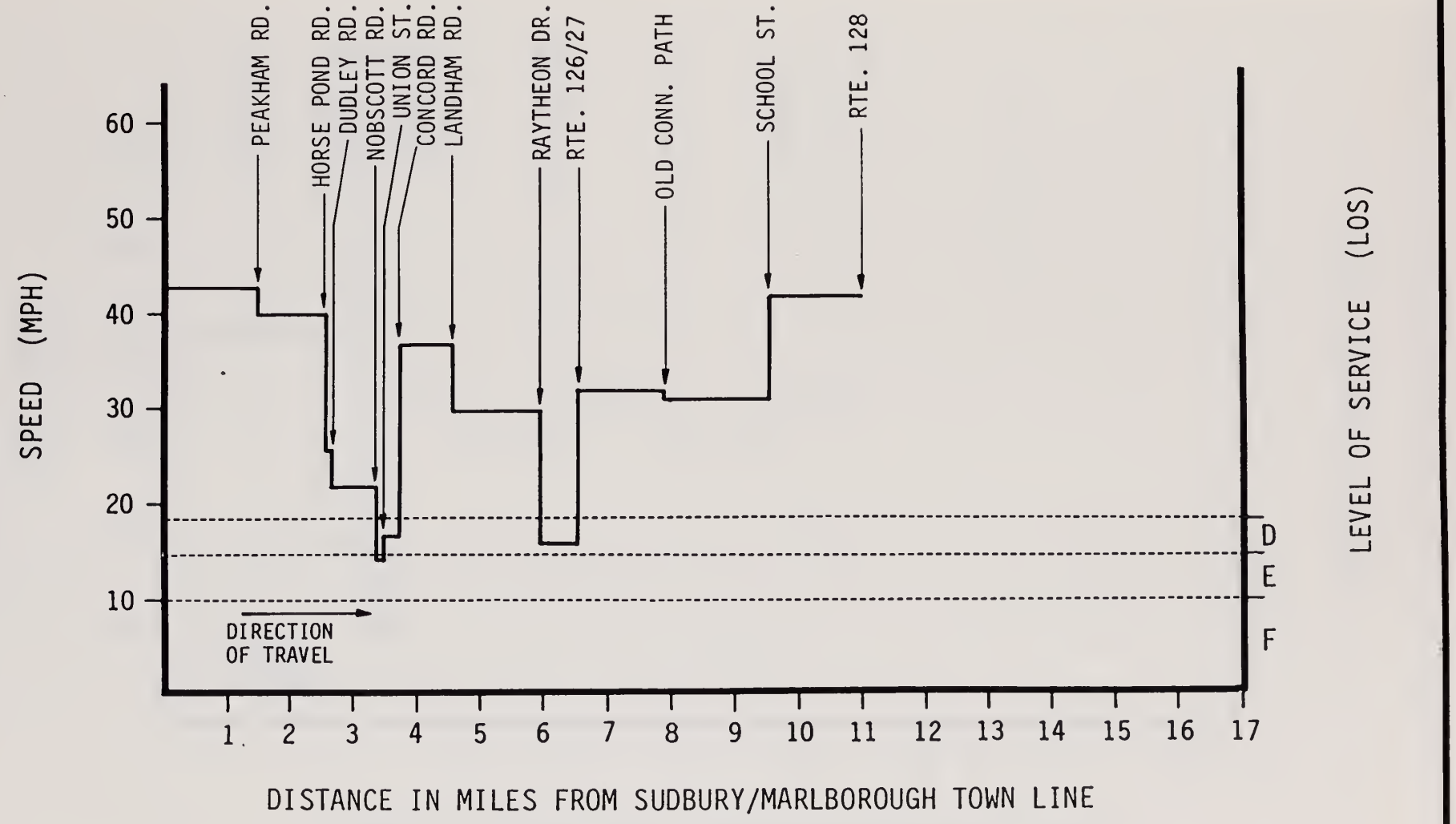
Fig. 3-b ROUTE 20 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
WESTBOUND

MAPC



Source: Vanasse-Hangen

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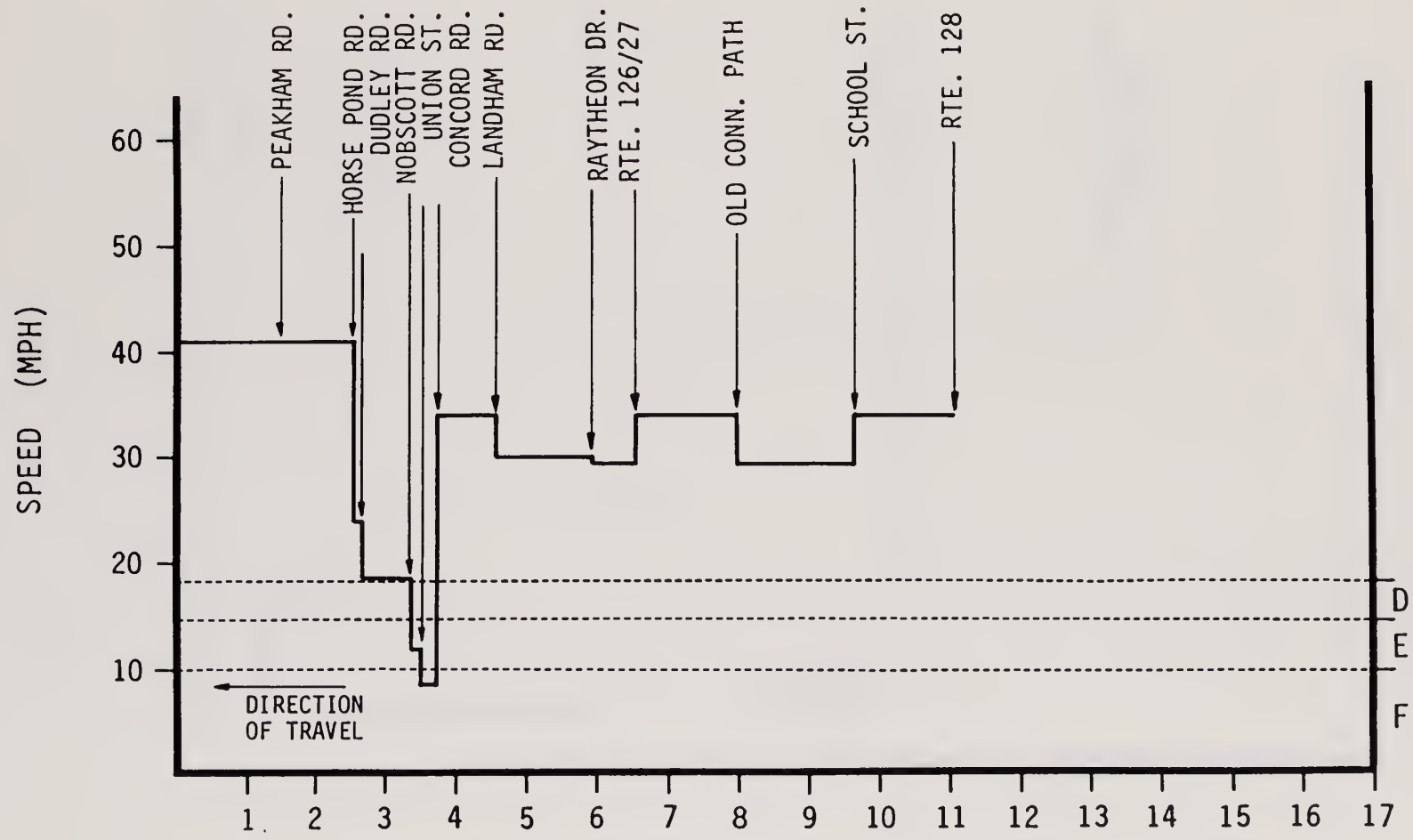
Fig. 3-c ROUTE 20 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
EASTBOUND

MAPC

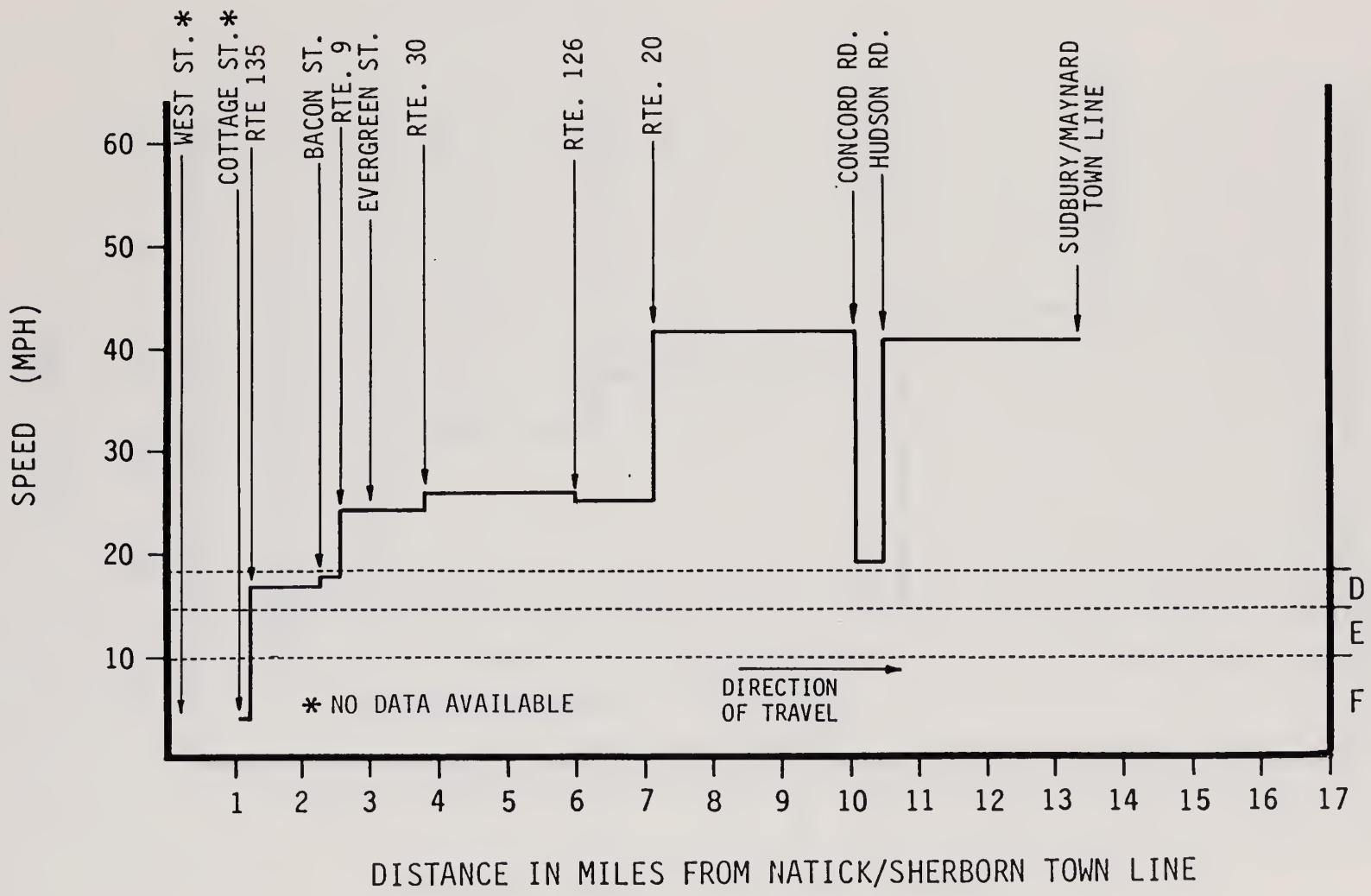


Source: Vanasse-Hangen

MetroWest
Speed and Delay Study
April 1986

Fig. 3-d ROUTE 20 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
WESTBOUND

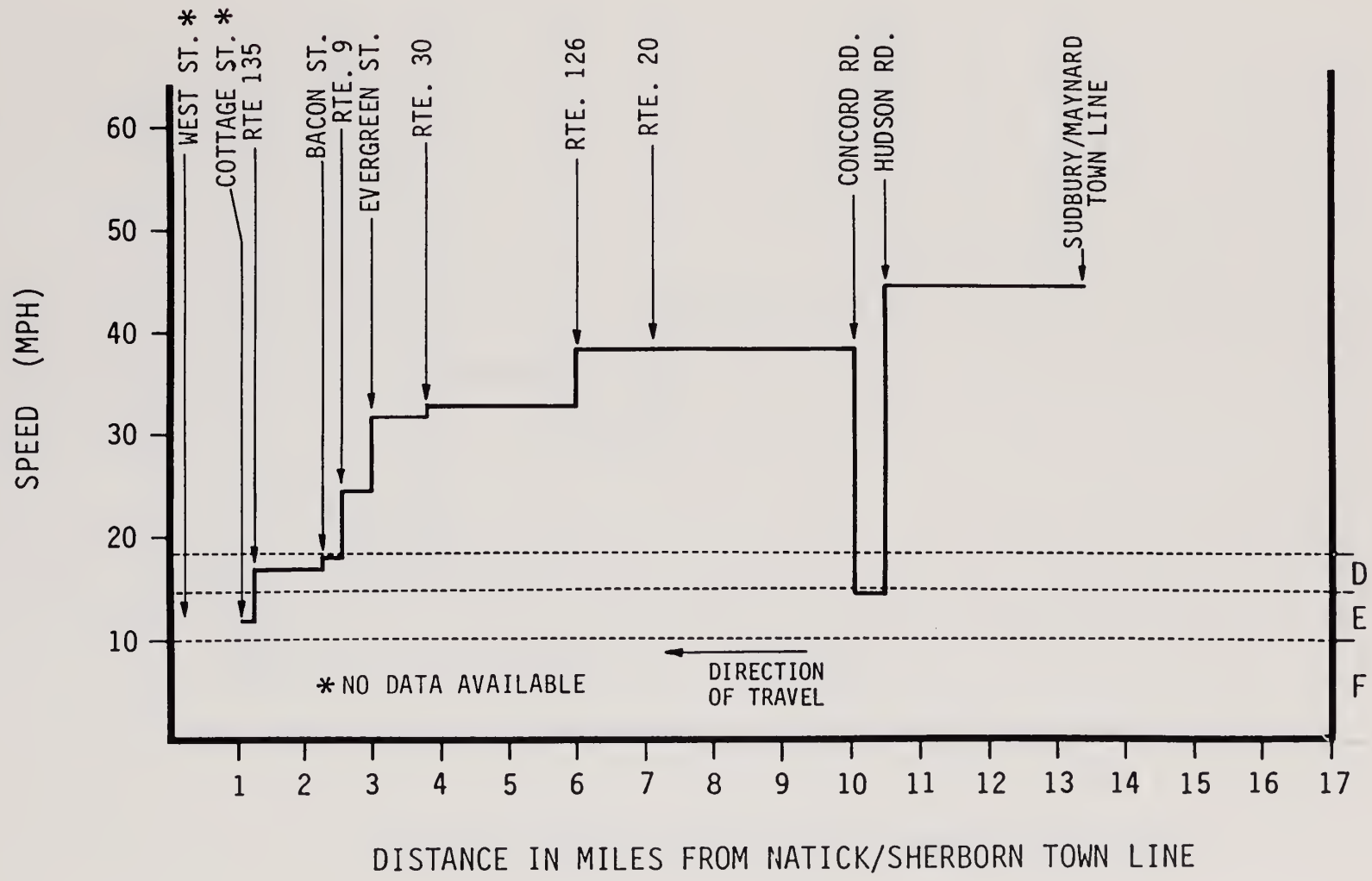
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 4-a RTE 27 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
NORTHBOUND

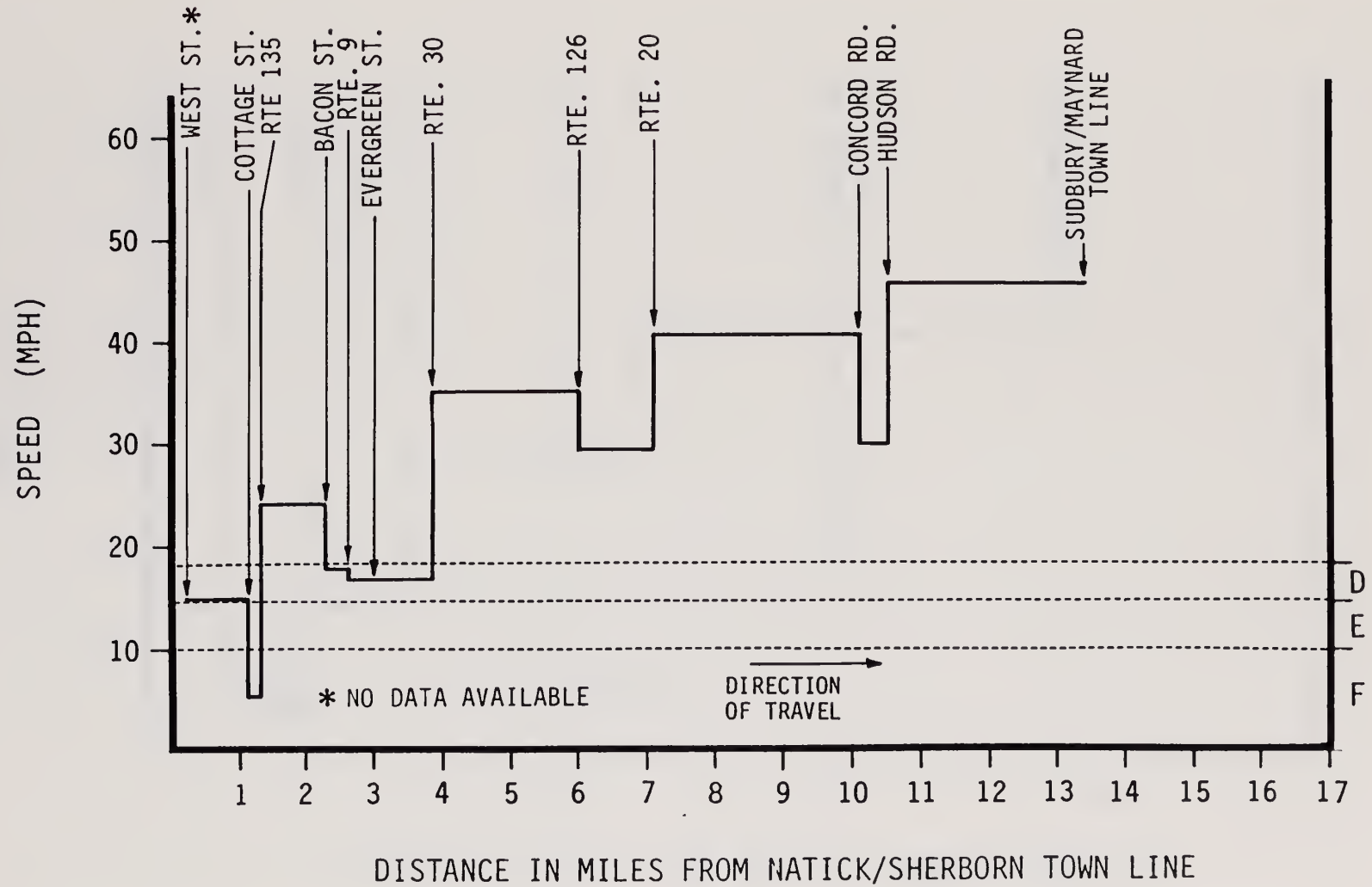
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 4-b RTE 27 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
SOUTHBOUND

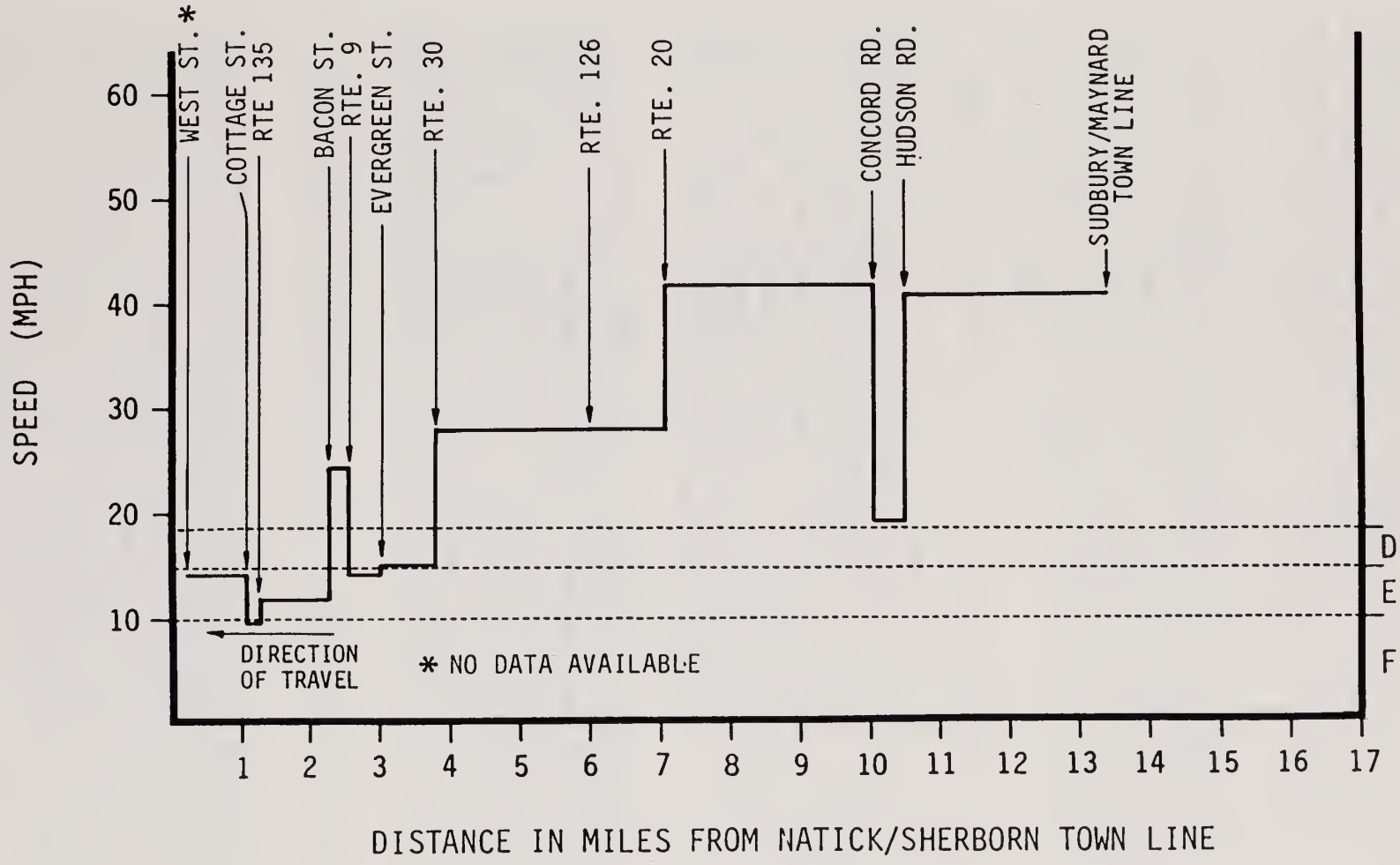
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 4-c RTE 27 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
NORTHBOUND

MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 4-d RTE 27 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
SOUTHBOUND

MAPC

4. Route 30 (Johnson Road <Southborough> to Route 128 <Weston/Newton Town Line>)

Westbound traffic moves about 15 mph faster through Southborough from Framingham Road to Route 85 than the eastbound during the morning peak period (Figures 5-a and 5-b). Both directions slow when approaching Speen Street and again at Wellesley Road. Eastbound traffic between Route 9 and Route 126 operates at LOS D.

During the afternoon peak period, Route 30 operates at LOS E in both directions between Route 85 and Newton Street in downtown Southborough (Figures 5-c and 5-d). As in the morning, our sample shows that both directions gradually slow as they approach Route 9. Between Route 27 and Route 126, westbound, speeds drop by over 20 mph. Route 30 traffic, eastbound, operates at LOS D between Route 9 and Speen Street and then gradually speeds up as it travels away from the Natick shopping centers.

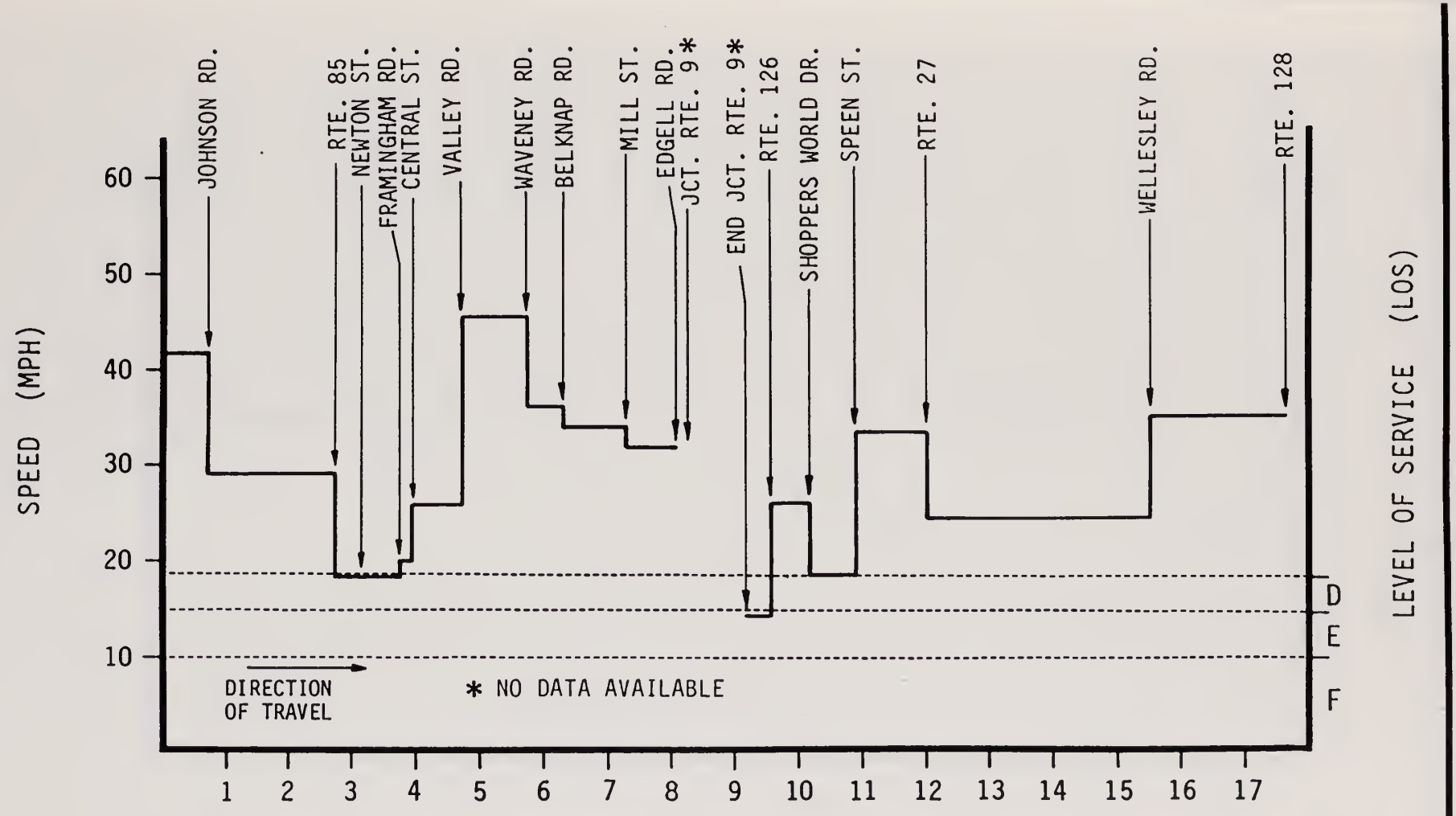
5. Route 126 (Ashland/Holliston Town Line to Route 117 <Lincoln>)

Congestion occurs during the morning peak period at the approaches to Route 135 from both directions (Figures 6-a and 6-b). Northbound traffic from Winthrop Street operates at just over 10 mph (LOS E) as does the southbound from Hartford Street. Traffic from either direction is observed to speed up from either direction once it clears its southernmost intersection with Old Connecticut Path and again at the southernmost junction with Route 27. Traffic is heavily congested between Route 20 and the northern junction with Route 27, with both directions operating at LOS F.

As in the morning, severe traffic congestion occurs at the approaches to Route 135 during the afternoon. Northbound traffic operates at LOS E between Winthrop Street and Hartford Street (Figure 6-c). From Hartford Street to Route 135 southbound, traffic creeps along at 6 mph or LOS F. Southbound traffic is also slowed from Route 9 to Hartford Street, operating at LOS E (Figure 6-d). The approaches to Route 20 are relatively congested, with southbound traffic from the northern junction with Route 27 to Route 20 functioning at LOS F.

6. Route 135 (Ashland/Hopkinton Town Line to Wellesley/Needham Town Line)

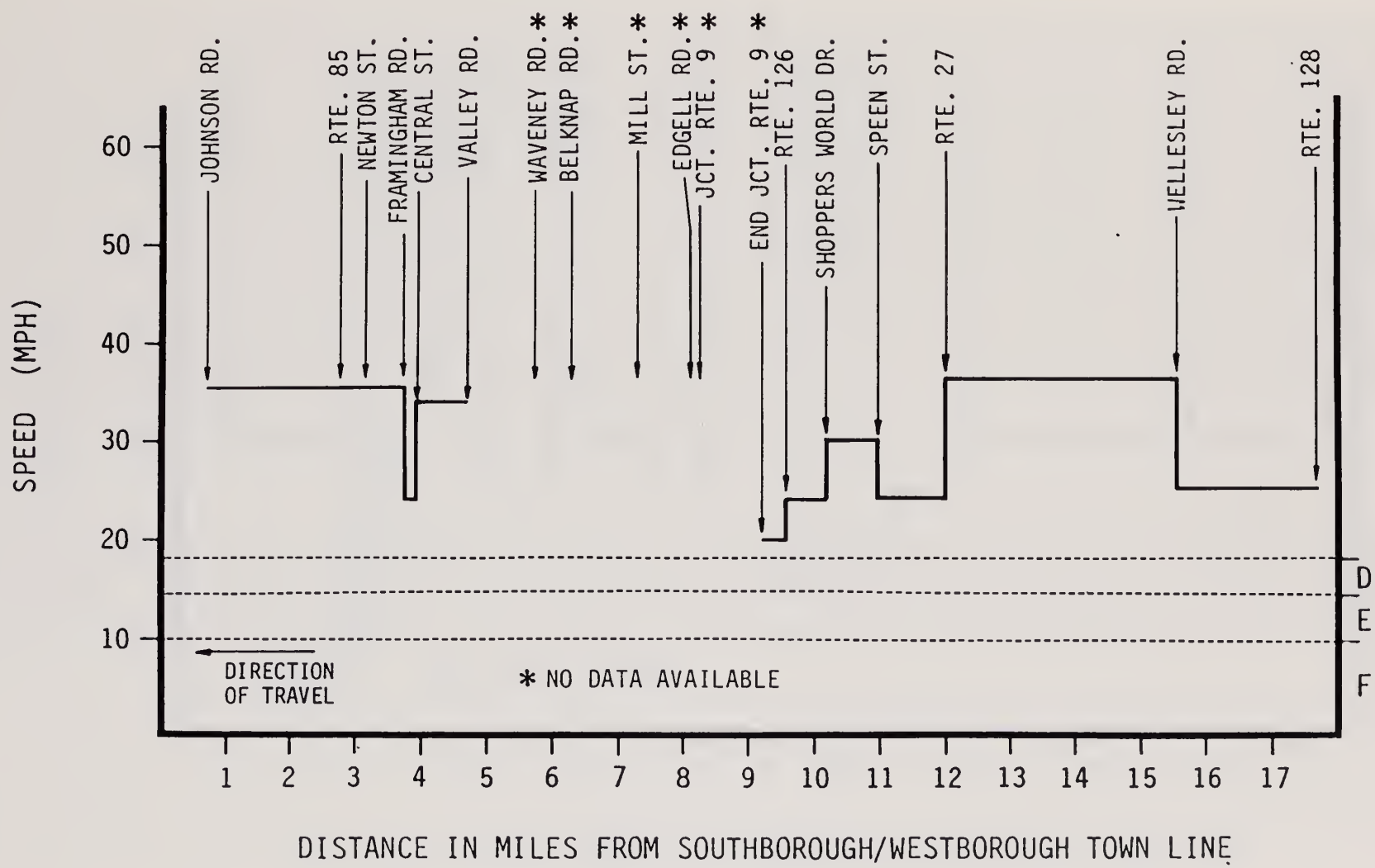
During the morning peak period, eastbound traffic on Route 135 between Ashland and Natick generally moves faster than westbound (Figures 7-a and 7-b). Speeds take a sharp drop from either direction at the approaches to Route 126 and between Mill Street and Speen Street. Travel is greatly impeded in both directions at the approaches to Route 27, moving at less than 12 mph. Morning eastbound traffic along the overlap of Routes 135 and 16 to Weston Road operates at LOS D or less. Westbound traffic is slowed in the vicinities of Route 16, Route 27, Speen Street and Route 126, but not as severely as the eastbound.



MetroWest
Speed and Delay Study
April 1986

Fig. 5-a ROUTE 30 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
EASTBOUND

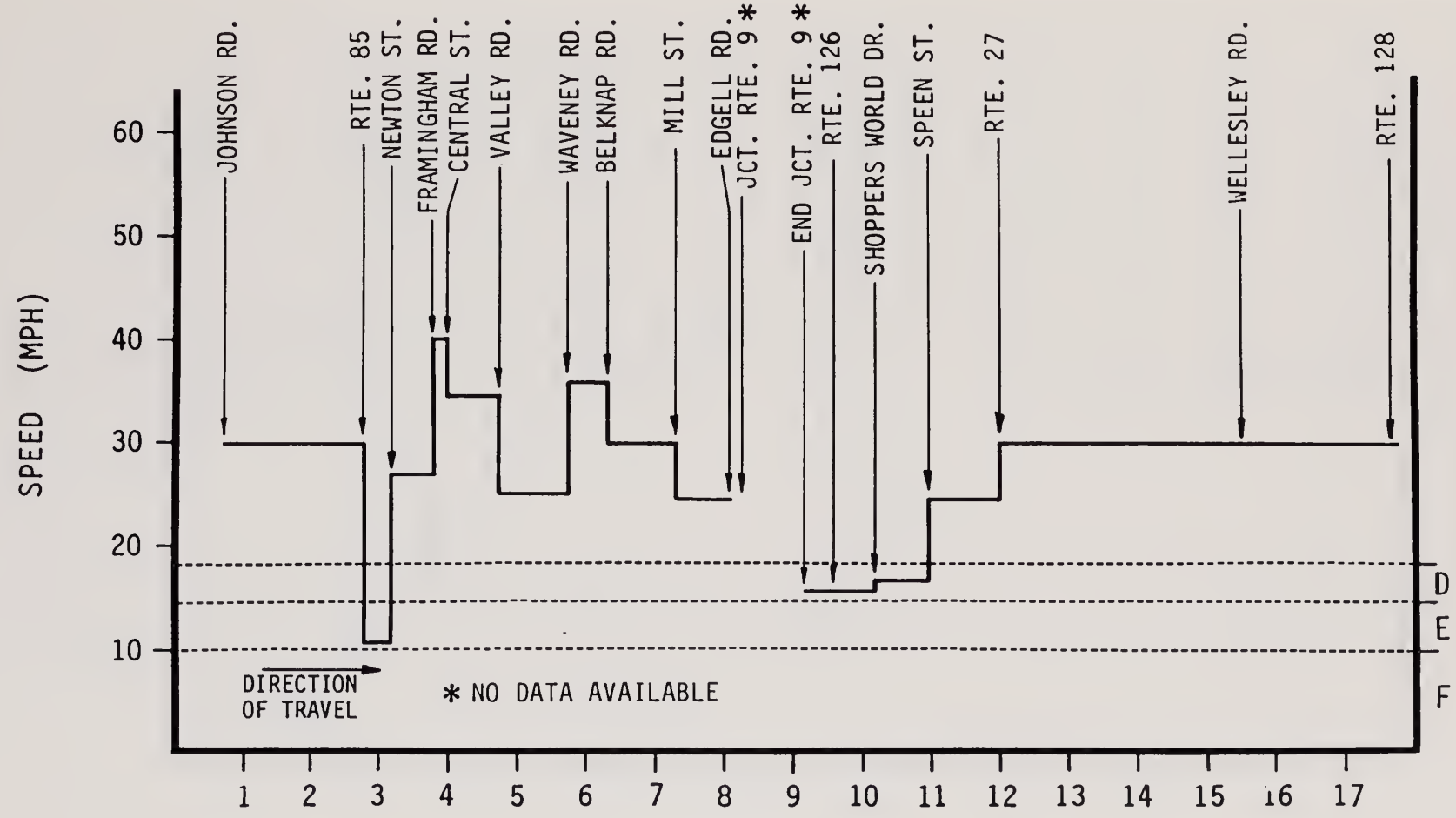
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 5-b ROUTE 30 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
WESTBOUND

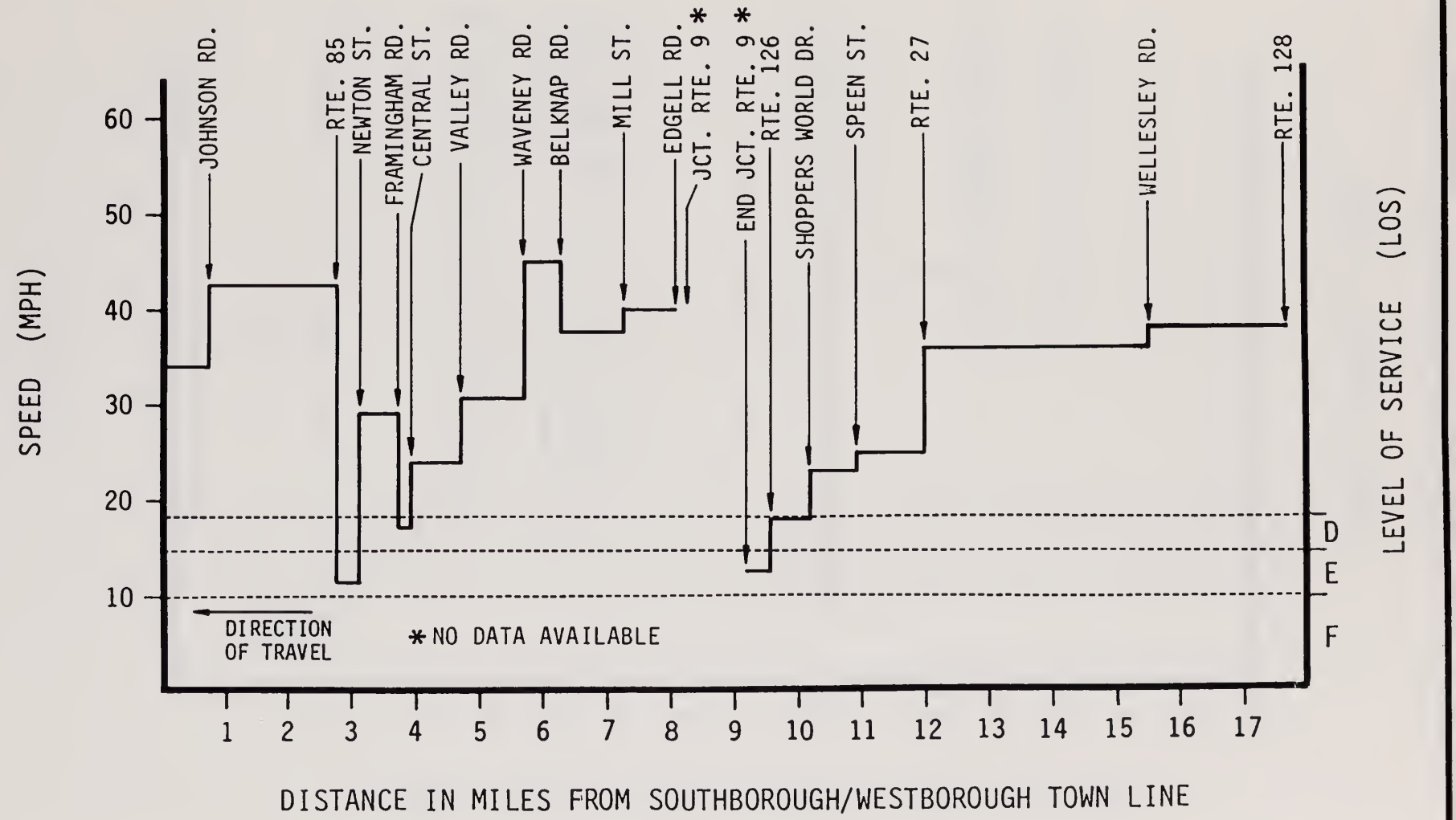
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 5-c ROUTE 30 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
EASTBOUND

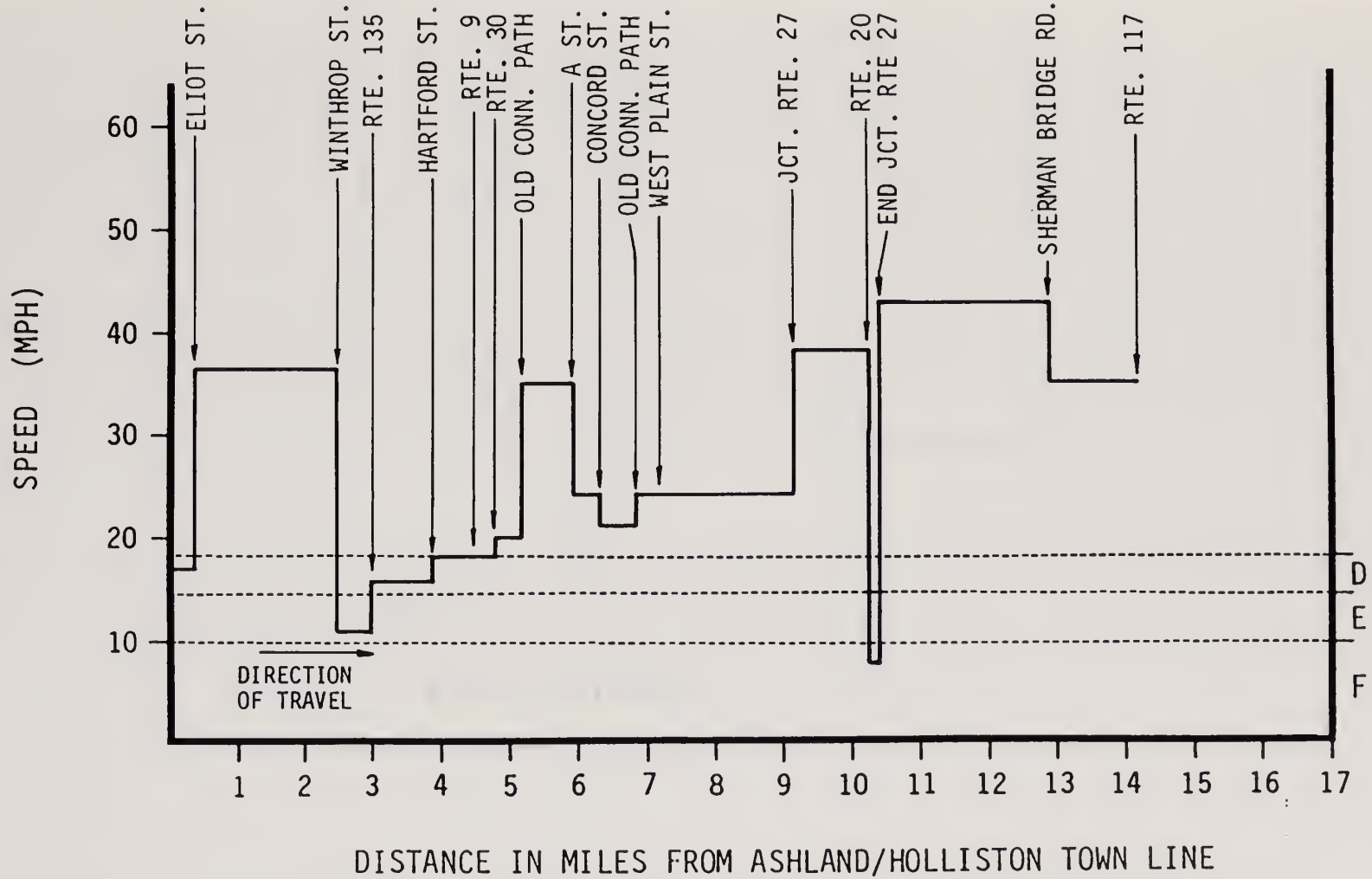
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 5-d ROUTE 30 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
WESTBOUND

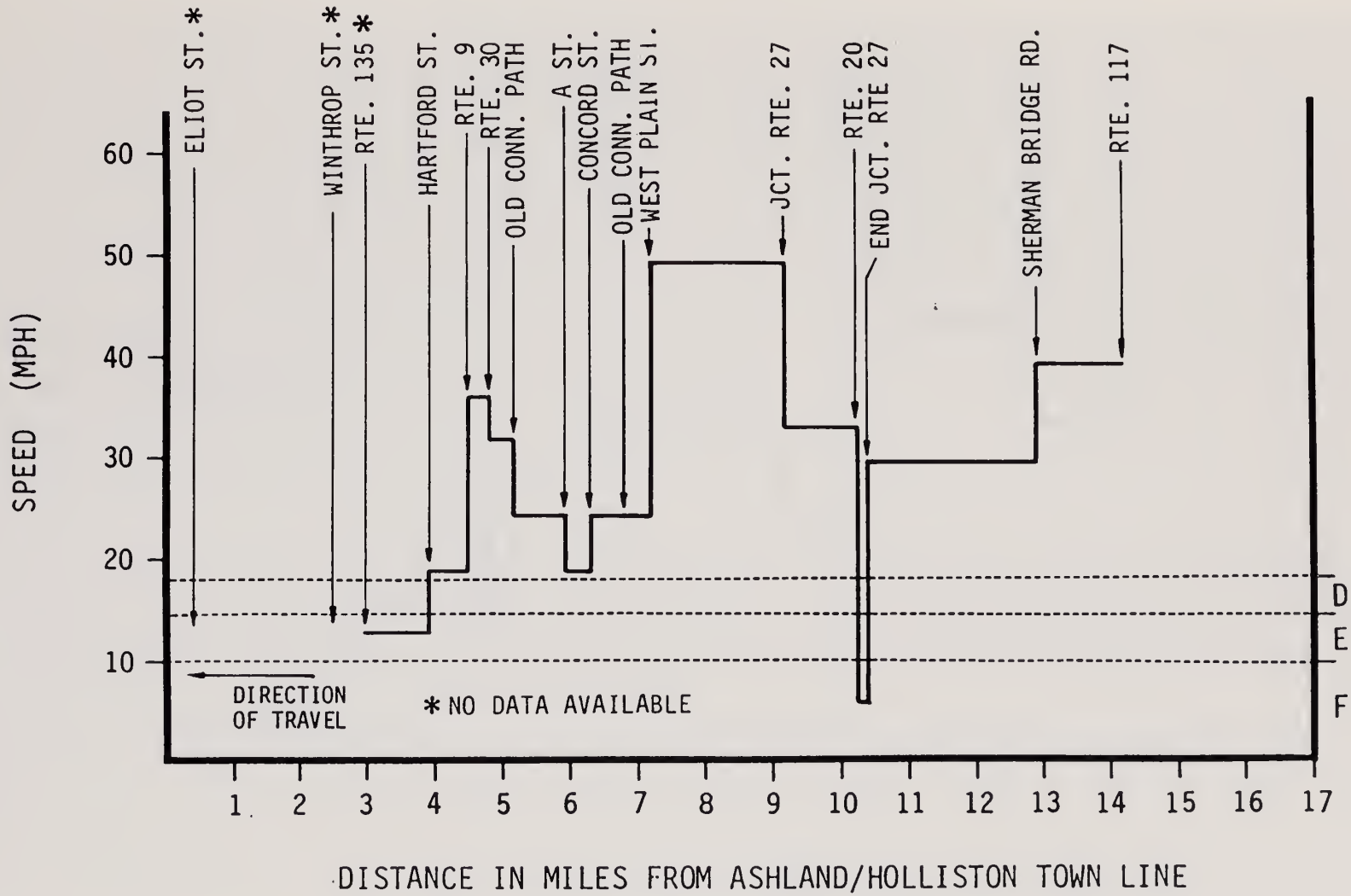
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 6-a ROUTE 126 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
NORTHBOUND

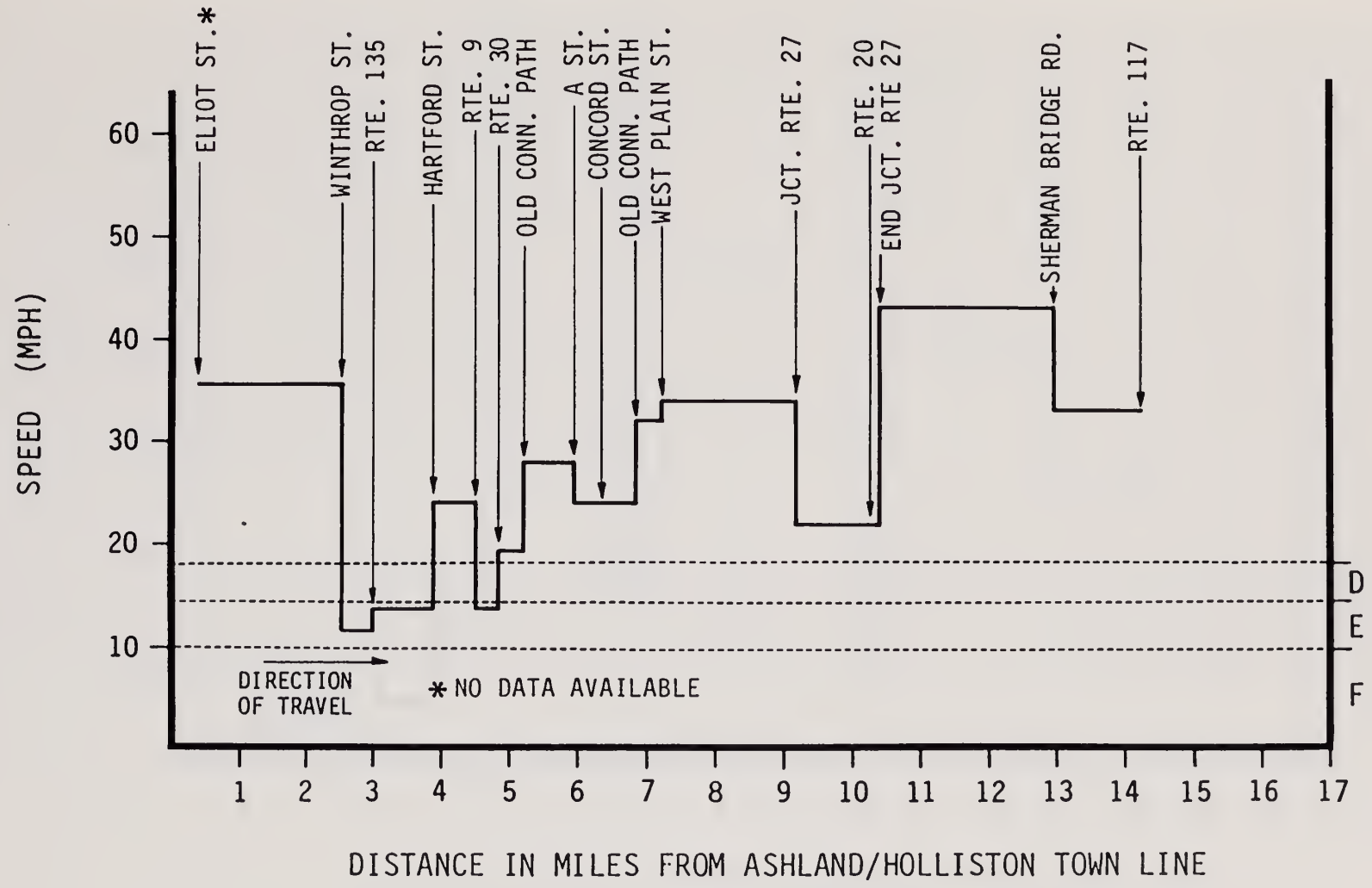
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 6-b ROUTE 126 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
SOUTHBOUND

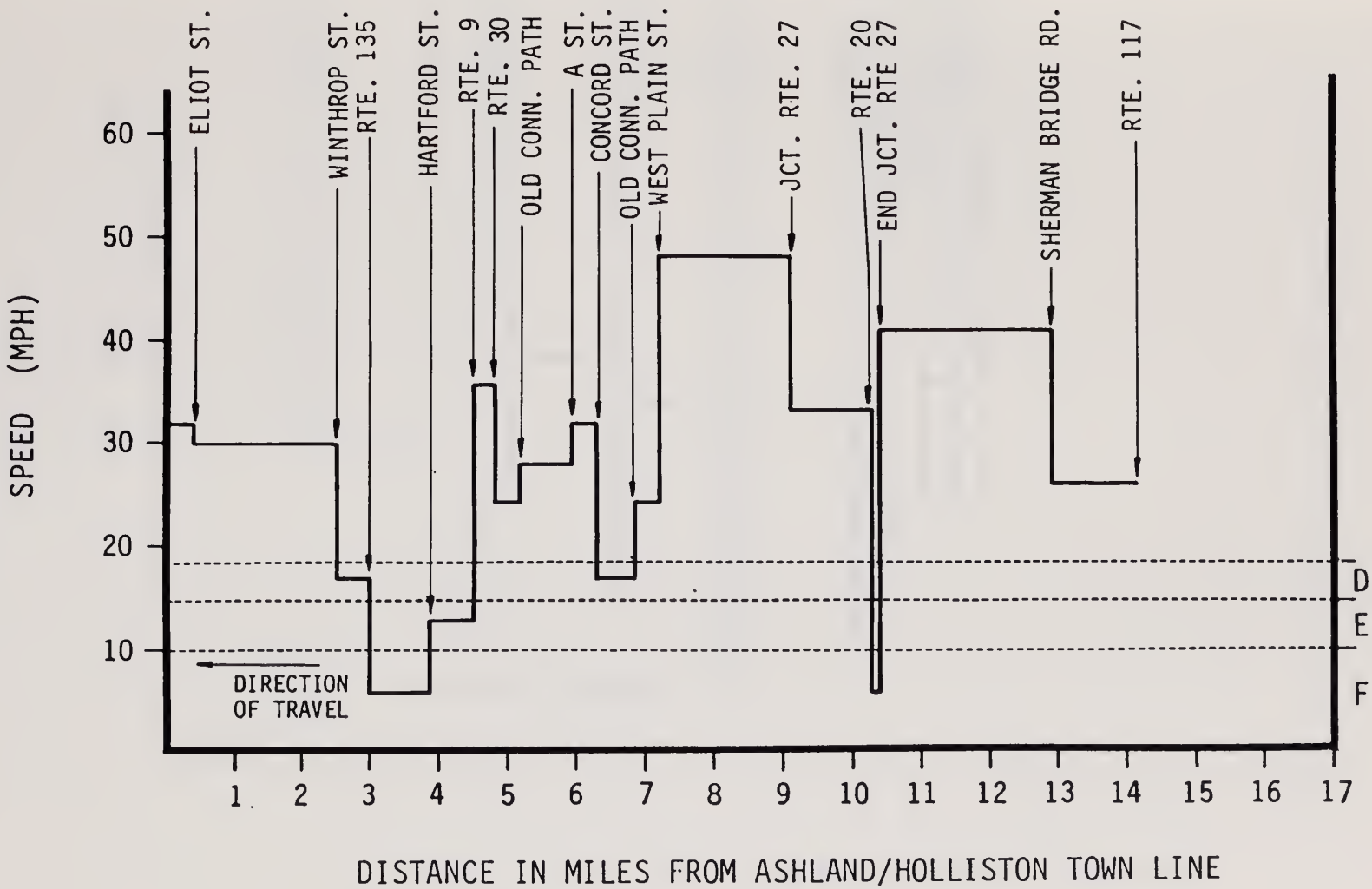
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 6-c ROUTE 126 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
NORTHBOUND

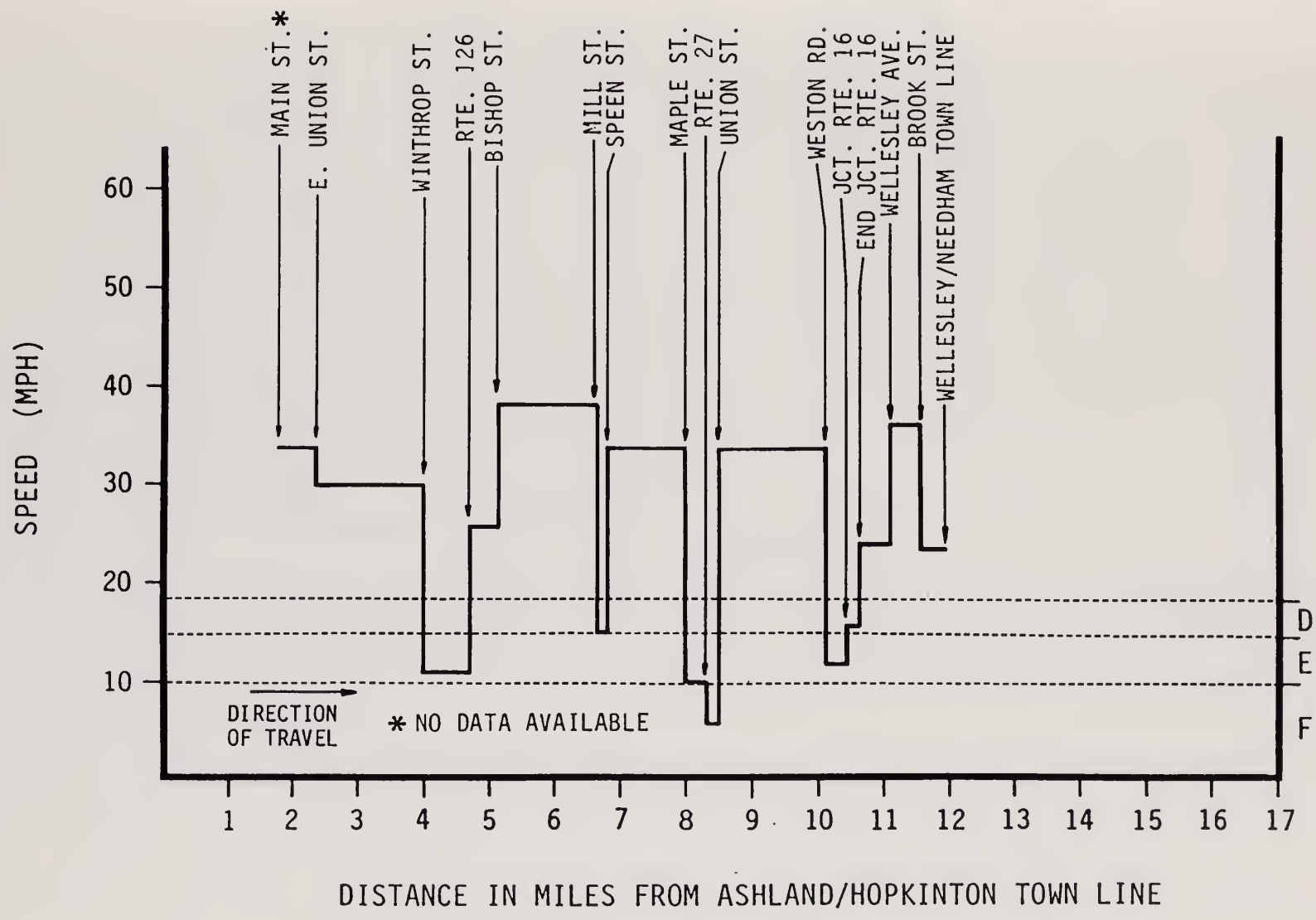
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 6-d ROUTE 126 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
SOUTHBOUND

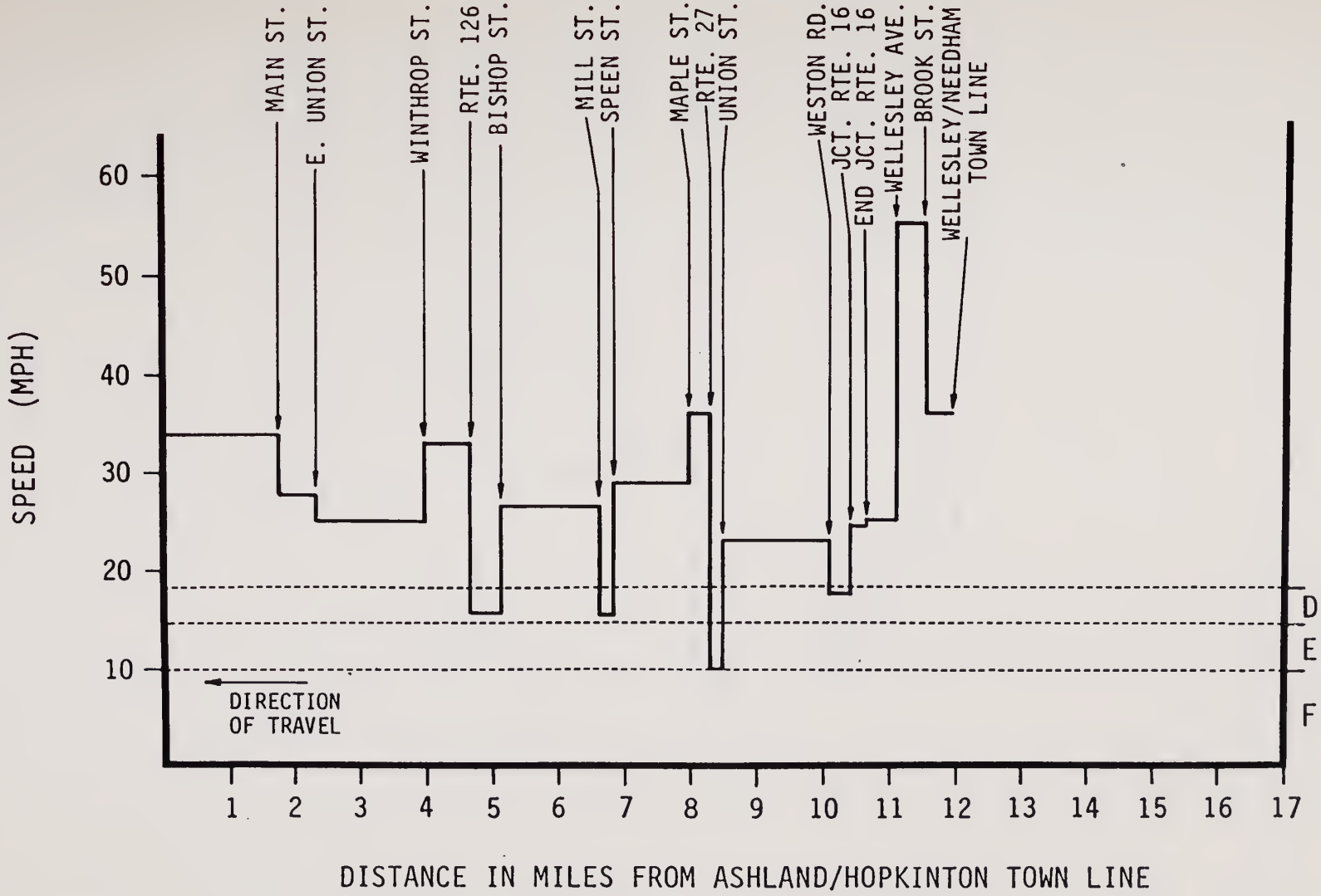
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 7-a ROUTE 135 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
EASTBOUND

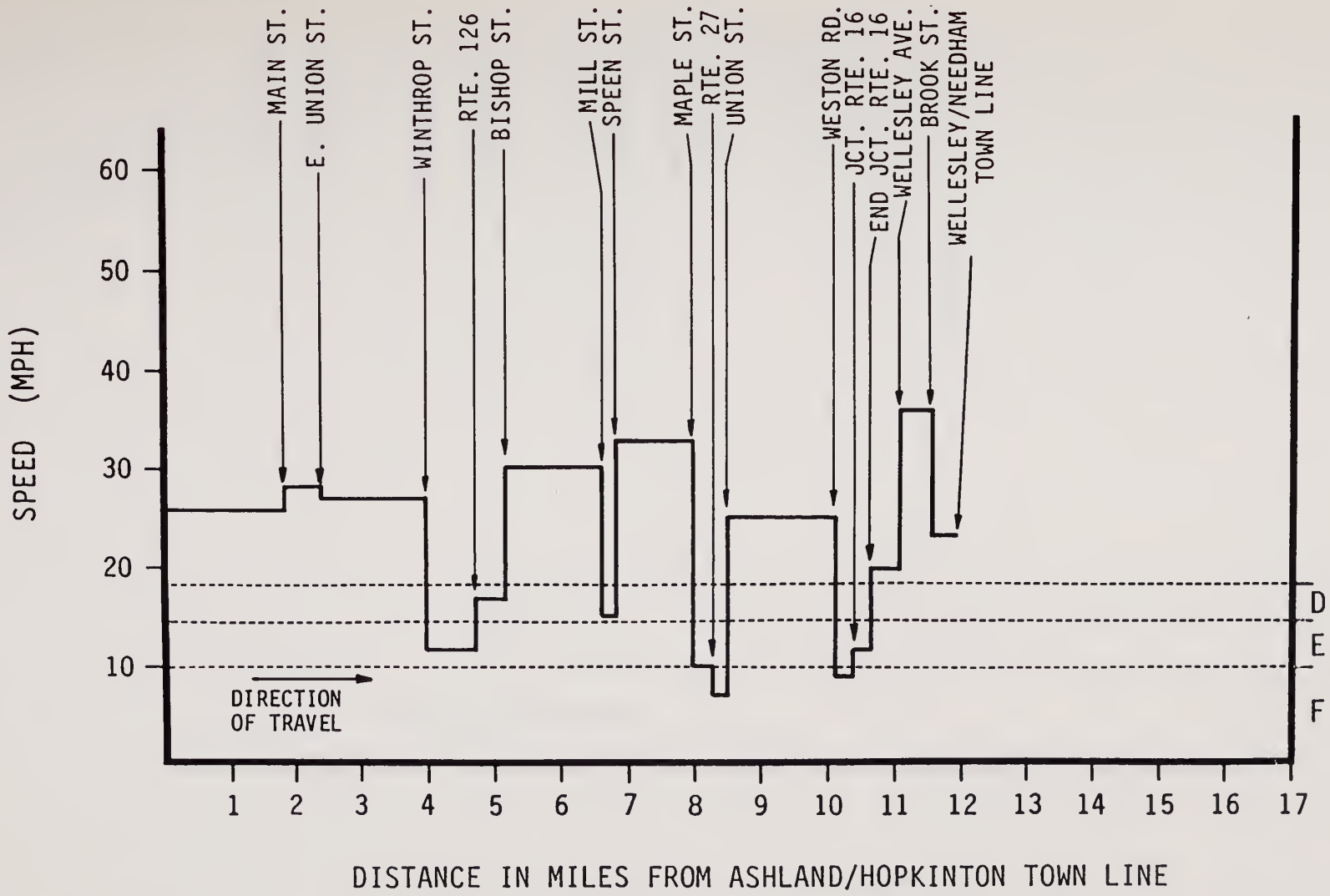
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 7-b ROUTE 135 AVERAGE TRAVEL SPEEDS
AM PEAK PERIOD
WESTBOUND

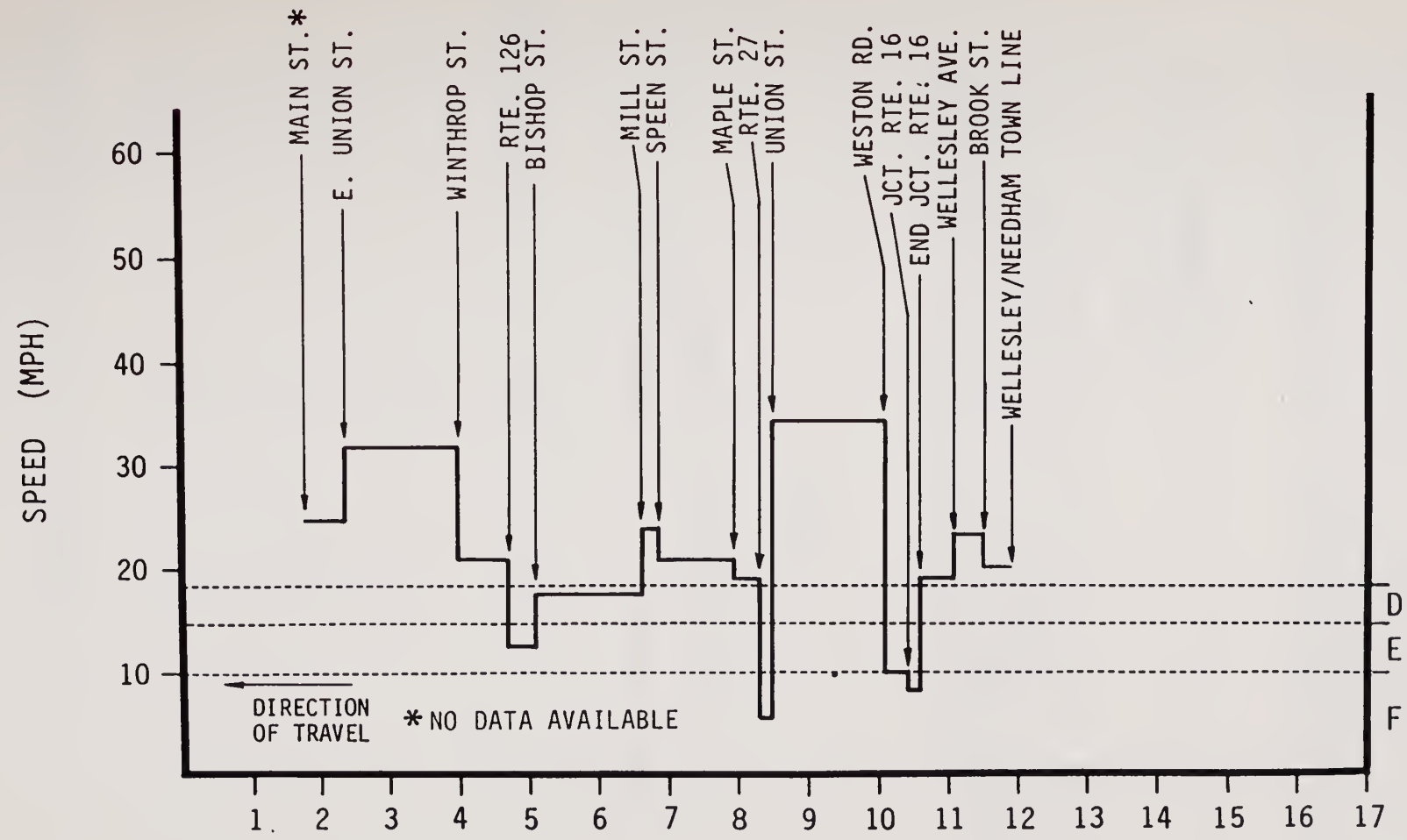
MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 7-c ROUTE 135 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
EASTBOUND

MAPC



MetroWest
Speed and Delay Study
April 1986

Fig. 7-d ROUTE 135 AVERAGE TRAVEL SPEEDS
PM PEAK PERIOD
WESTBOUND

MAPC

During the afternoon peak period, both eastbound and westbound approaches to Route 126 function at LOS E (Figures 7-c and 7-d). Eastbound traffic operates at LOS D as it approaches Speen Street and at LOS E between Maple Street and Route 27. Both directions function at less than 10 mph, or LOS F, between Route 27 and Union Street. As in the morning, traffic along the overlap of Route 16 and Route 135 is heavily congested. Both directions operate at less than 12 mph between Weston Road and the eastern junction of Route 135 and Route 16.

V. INTERSECTION ANALYSIS

A. Regional Summary

Forty-six intersections are deficient in the morning compared to sixty in the afternoon, offering further support for the finding that traffic congestion is worse in the afternoon peak period (Table 2). The categories D, E, and F indicate at least one approach is operating at the specified level of service, and "FF" denotes that at least two or more approaches operate at LOS F.

Table 2

Number of Intersections with

Level of Service D, E, or F at Worst Approach

Level of Service	AM	PM
D	20	16
E	10	19
F	13	19
FF*	3	6
Total	46	60

* level of service F at two worst approaches

The average delays observed at intersections are shown on Maps 4 and 5 for the morning and afternoon peak periods respectively. The size of the circle on the map indicates the level of service (LOS) associated with the intersection it represents. The smallest three circles in order of ascending size represent intersections with at least one approach (i.e. the worst approach) at LOS D, E, or F, respectively. The largest circle represents the worst intersections, those with two or more approaches operating at LOS F.

Most of the intersection delays occur in the town centers or along the major state highways during both peak periods. However, delays are also experienced at intersections along Main Street in Ashland and Edgell Road in Framingham, Speen Street, and other town roads as well.

During the morning peak period, average delays of one minute or longer (LOS F) are experienced at two or more approaches to the intersections of Route 135 and Route 126; Route 27 and Route 135; Speen Street and Route 30, and Main Street and Chestnut Street in Ashland (Map 4).

These same intersections, with the exception of Main at Chestnut Street in Ashland, are also heavily congested with at least two approaches operating at LOS F in the afternoon peak period. As with speeds along segments, intersections are generally worse in the afternoon than the morning in terms of both number deficient and degree of severity. Other intersections that are worse in the afternoon, with more than a minute's wait at 2 or more approaches are Bishop Street and Route 135 (Framingham), Union Street and Route 20 (Sudbury), and Wellesley Street and Route 30 (Weston).

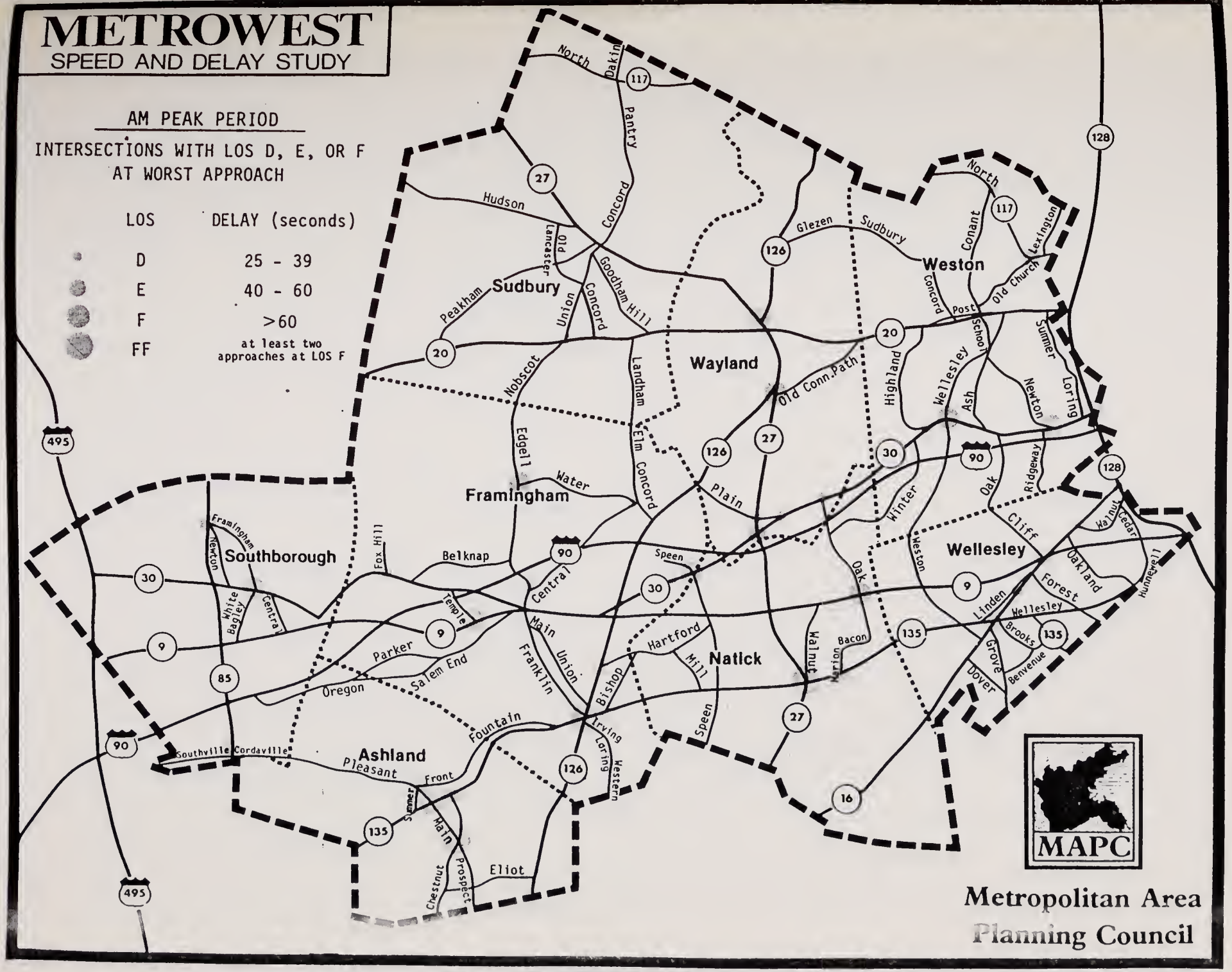
Route 9 is out of the jurisdiction of this study (see Route 9 Corridor Study by CTPS, 1986), but it was found that the intersections with Route 9 and Temple Street, Speen Street and Oak Street were operating at LOS F for the northbound and southbound approach(es).

B. Problem Intersections

1. Ranking System Used

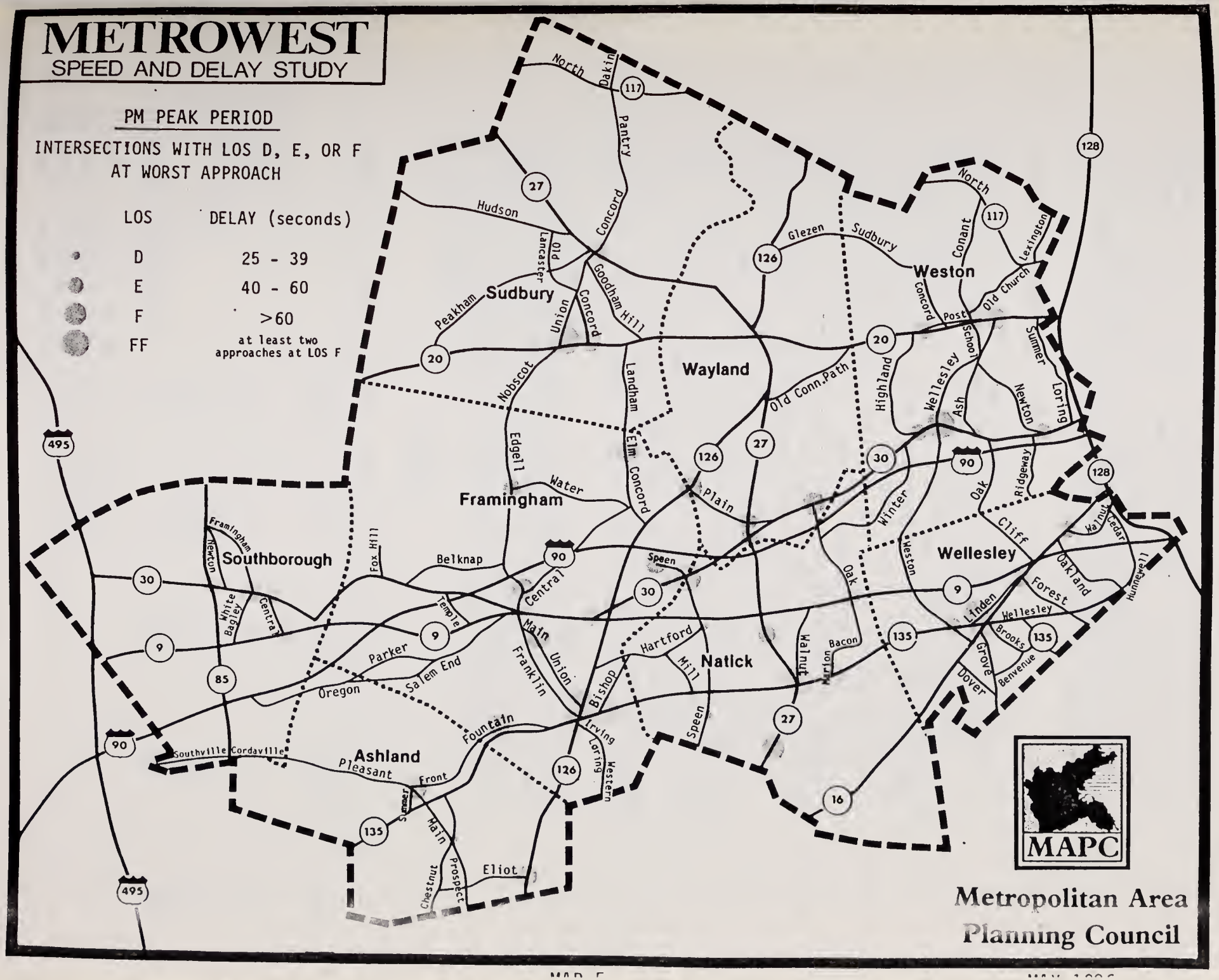
A ranking system was developed and used to derive a score for each intersection studied with LOS F receiving 6 points and descending to 1 point for LOS A. Scores for all approaches were summed and divided by the total number of approaches to the intersection, to construct a measure of level of service for the intersection overall.

If no data was collected for an approach because no runs were made through it, a value of 3.5 was assigned which is equivalent to halfway between LOS C and LOS D. The value 3.5 may tend to be a little on the high side, in that some of the approach roads are of a lower functional classification, with less traffic. The ranking system used is not perfect by any means, but does serve as a first step in addessing intersection problems on a subregional basis.



MAP 4

MAY 1986


METROWEST
SPEED AND DELAY STUDY
PM PEAK PERIOD
INTERSECTIONS WITH LOS D, E, OR F
AT WORST APPROACH
LOS
DELAY (seconds)
D
25 - 39
E
40 - 60
F
>60
FF
at least two approaches at LOS F
Sudbury
Wayland
Framingham
Weston
Natick
Wellesley
Southborough
Ashland
MAPC
Metropolitan Area
Planning Council

2. Results

Table 3 lists those intersections with more than one deficient approach and ranks them according to a level of service rating for the entire intersection. There are 12 and 16 intersections with multiple deficient approaches in the morning and afternoon peak periods, respectively. The number of approaches studied and the total number of existing approaches are listed for each case, and the level of service at each deficient approach is identified.

VI. Traffic Improvements in Progress

Information on traffic improvements in progress was obtained by interviews with local DPW's, planning departments, and town administrators (5). This information is summarized by three categories (Table 4). The first includes those projects listed in the 1986-1990 Transportation Improvement Program (TIP) which the Massachusetts DPW expects to implement within the next five years (excluding bridge reconstruction). All of the TIP projects in MetroWest are anticipated to receive federal aid. The second category includes projects which have been approved and funded. These projects are not found in the TIP and therefore will not be federally funded. These projects are usually not big enough to request federal funding or are on town roads which are not eligible. While 100% state funded projects could be included in this category, all of the MetroWest projects listed are 100% locally funded. The third category of the work to date is a catch-all for those projects which may have preliminary design work begun, or may be ready for implementation pending approval and a funding mechanism. Also included are those projects which have simply been identified through a formal traffic study, and a solution proposed.

A comparison was made to see which of the problems identified by this study had been previously addressed in one of the above three categories, and the type of progress to date (Table 5). It was found that of a total of 74 intersections with the worst approach operating at LOS D, E, or F in either the AM or PM peak period, 32 of them had been previously studied. Of these, 13 are currently approved projects.

Table 5

Number of Existing Problems at Deficient Intersections by Level of Service

	LOS D[1]	LOS E[2]	LOS F[3]	LOS FF[4]	TOTAL
Intersections Identified (AM and PM)	20	18	29	7	74
Existing Projects	10	10	8	4	32
(TIP)	(3)	(3)	(3)	(3)	(12)
(Others Approved)	(0)	(0)	(1)	(0)	(1)
(Studies and Unapproved)	(7)	(7)	(4)	(1)	(19)

1) The worst approach is at level of service D
2) The worst approach is at level of service E
3) The worst approach is at level of service F
4) The worst two approaches are at level of service F.

Table 3 MetroWest Speed and Delay
Intersections with Level of Service D,E, or F at More Than One Approach
Ranked by Descending Order of Severity

AM Peak Period	Number of Approaches			
	No. Studied of Total	LOS F	LOS E	LOS D
Rt. 135, Rt. 126 & Irving St.	5 of 5	3	-	1
Rt. 30 & Wellesley St.	4 of 4	1	1	2
Rt. 27 & Rt. 135	4 of 4	2	-	1
Chestnut St. & Main St.	2 of 4	2	-	-
Edgell Rd. & Water St.	3 of 3	1	1	-
Rt. 30 & Speen St.	4 of 4	2	-	-
Rt. 20 & School St.	4 of 4	-	2	1
Rt. 135, Union St., & Marion St.	3 of 4	-	1	2
Rt. 20 & Rt. 27/126	4 of 4	-	-	3
Rt. 135 & Bishop St.	2 of 3	-	2	-
Rt. 126, Rt. 27 & Old Conn Path	3 of 4	1	-	1
Central St. & Water St.	3 of 3	-	-	2
PM Peak Period				
Rt. 135 & Bishop St.	3 of 3	2	-	1
Speen St. & Rt. 30	4 of 4	1	3	-
Rt. 27 & Rt. 135	4 of 4	2	1	1
Rt. 20 & Union St.	3 of 3	2	-	-
Rt. 30 & Wellesley St.	4 of 4	2	-	1
Rt. 126, Rt. 135, & Irving St.	4 of 5	2	1	-
Rt. 20 & School St.	4 of 4	1	1	-
Rt. 135 & Union St.	3 of 4	1	1	-
Rt. 27 & Rt. 30	4 of 4	-	1	1
Rt. 30 & Rt. 126	4 of 4	-	1	1
Rt. 20 & Concord Rd.	2 of 3	1	-	1
Rt. 135 & Grove St.	3 of 3	1	-	1
Water St. & Edgell Rd.	3 of 3	-	1	-
Rt. 27 & Concord Rd.	4 of 4	1	-	1
Rt. 135 & Weston Rd.	4 of 4	-	1	1
Linden St., Forest St., & Rockland St.	5 of 5	-	2	1

TABLE 4

INVENTORY OF PROPOSED TRAFFIC IMPROVEMENTS

Town	FY 86-90 TIP Projects * (Excluding Bridge Reconstruction)		Other Approved Projects ** (Excluding TIP)		Studies and Other Unapproved Projects	
	Location	Project Type	Location	Project Type	Location	Project Type
Ashland	1) Main St., Pleasant St. 2) 5 Locations: a) Union St. at Summer St. b) Union St. at Main St. c) Union St. at Chestnut St. d) Union St. at Fountain St. e) Prospect St. at Chestnut	Reconstruction Intersection Improvements	None		25) Cordaville Rd. at Winter St.	Intersection Redesign
Framingham	3) Rt. 9 at Temple St. 4) Rt. 9 at Prospect St. 5) Rt. 126 & Rt. 30 6) Rt. 30 from Burger King to Mass. Pike #13.	Right Turn Lane Signals Safety Improvement Reconstruction	11) Salem End at Winter St. 12) Arthur St. at Grant St. 13) Concord St. at Watson St. 14) Elm St. at Potter Rd.	Traffic Light Traffic Light Traffic Light Traffic Light	26) Rt. 9 at Rt. 30 West 27) Franklin St. at Main St. 28) Caldor Rd. at Rt. 9 29) Speen St. at Rt. 30 30) Saxonville Square	Intersection Improvements Traffic Lights Intersection Improvements Intersection Improvements Traffic Lights
Natick	7) Signals, 3 locations: a) Rt. 135 & Kendall Crossing b) Rt. 135 & 27 c) Hartford & Mill St.	Traffic Signals	15) Hoffmans at Rt. 9	U-Turn Reconstruction	31) Rt. 16 32) South Natick Square 33) Hartford St. at Speen	Reconstruction Intersection Improvements Intersection Improvements
Southborough	None		None		34) 3 locations: a) Framingham Rd. at Rte. 30 b) Rte. 30 at Central St. c) Framingham Rd. at Newton St.	Intersection Improvements
Sudbury	8) Rt. 20 (Dudley Rd. to Hop Brook) 9) 4 locations: a) Rt. 20 at Peakham Rd. b) Union Ave at Concord Rd. c) Concord Rd. at Pantry Rd. d) Rt. 117 at Haynes Rd.	Widening, signals & channelization Intersection Improvements	Multiple Intersections: 16) Dudley Rd. at Nobscott Rd. 17) Horsepond Rd. at Rte. 20 18) Dudley Rd. at Rte. 20 19) Pratts Mill Rd. at Willow 20) Pratts Mill Rd. at Peakham 21) Fairbanks Rd. at Hudson Rd. 22) Peakham Rd. at Hudson Rd. 23) Concord Rd. at Candy Hill	Low Cost Improvements	35) Boston Rd. at Valley, Willow & Firmin 36) Codger Lane 37) Rt. 27 & Concord Rd.	Intersection Improvements New drive for Raytheon from Codger Lane; cul-de-sac to prevent eastbound traffic onto Concord St. Intersection Improvement
Wayland	10) Rt. 27 (Main St.) at E. & W. Plain St.	Traffic Signal	24) Stone Bridge Rd.	Reconstruction	38) Rt 27 at Rt. 30 39) Rt. 27/126 at Rt. 20 40) Sherman Bridge Rd.	Intersection Improvements Intersection Improvements Reconstruction
Wellesley	None		None		41) Rt. 16 (from Weston Rd. to Newton Town Line) 42) Walnut St. (from Cedar St. to Rt. 16)	Reconstruction Reconstruction
Weston	None		None		None	

* MDPW projects, federally funded.
** Town projects, 100% town funded.

MAY 1986

Map 6 is a composit of worst cases found in the morning or afternoon. The worst approaches to intersections with a level of service of D, E, or F for the morning (Map 4) and afternoon (Map 5) are superimposed. The overlay to Map 6 visually summarizes the information found on Tables 5 and 6, showing the location of proposed projects and to what extent problem intersections have been addressed to date.

VII. Conclusions

Looking at the road system of this subregion as a whole gives a view of the locations and relative severity of traffic trouble spots for MetroWest commuters. The analysis of average speeds along segments and delays at intersections point to the intersections themselves as the trouble spots for traffic. Most bottlenecks can be alleviated by improvements at intersections, where possible, indicating no need to widen and to reconstruct roadway segments.

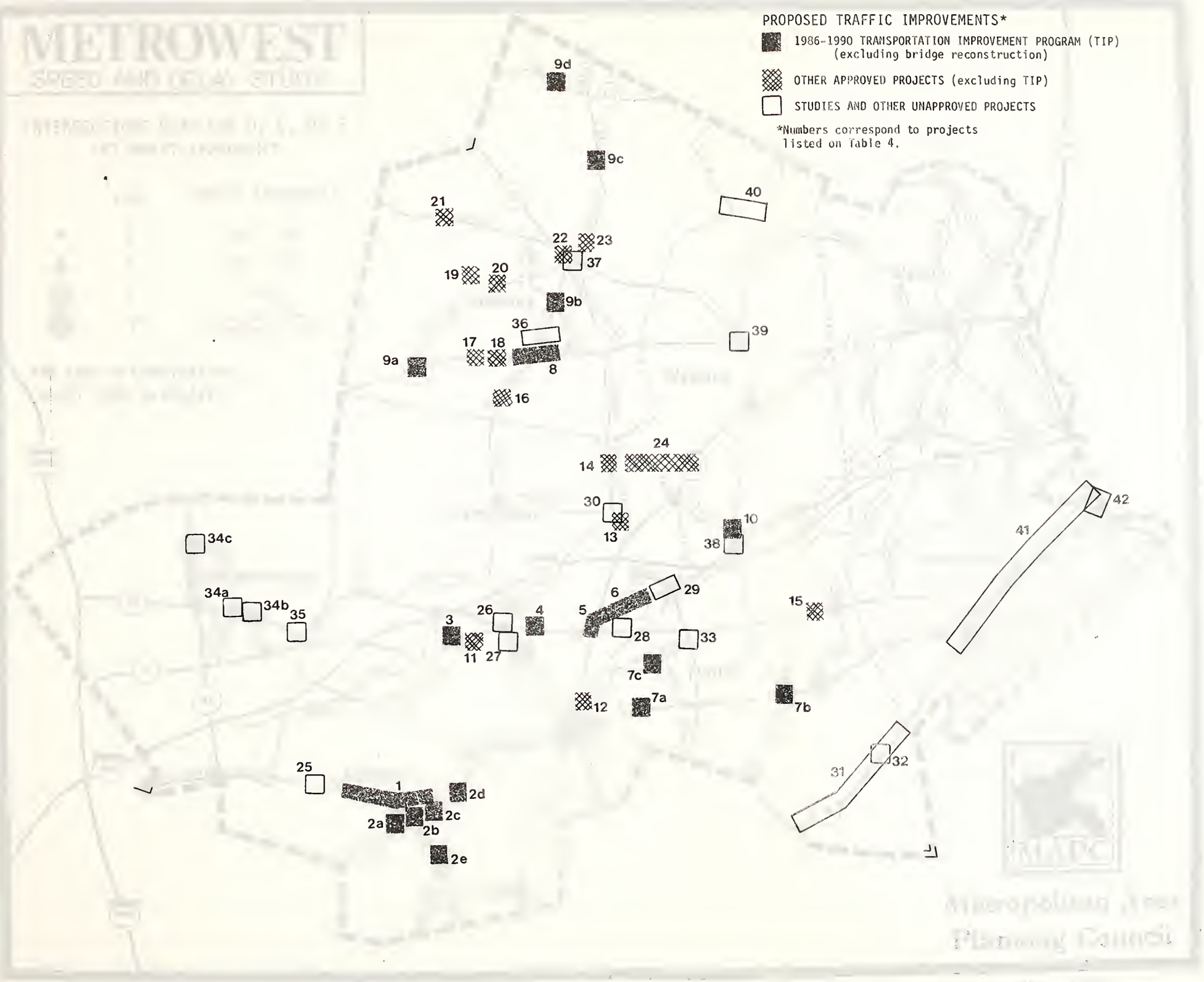
Acceptable solutions are limited because taking the right-of-way needed to make improvements at intersections would violate the character of these rural and historic towns, particularly in the downtown areas, i.e. Framingham. With development at its present pace in the region, improvements can never keep up or even catch up and congestion will continue to get worse. An analysis by MAPC of the relationship between land use and development to traffic on Route 9 and its implication for the future is found in a separate effort (6).

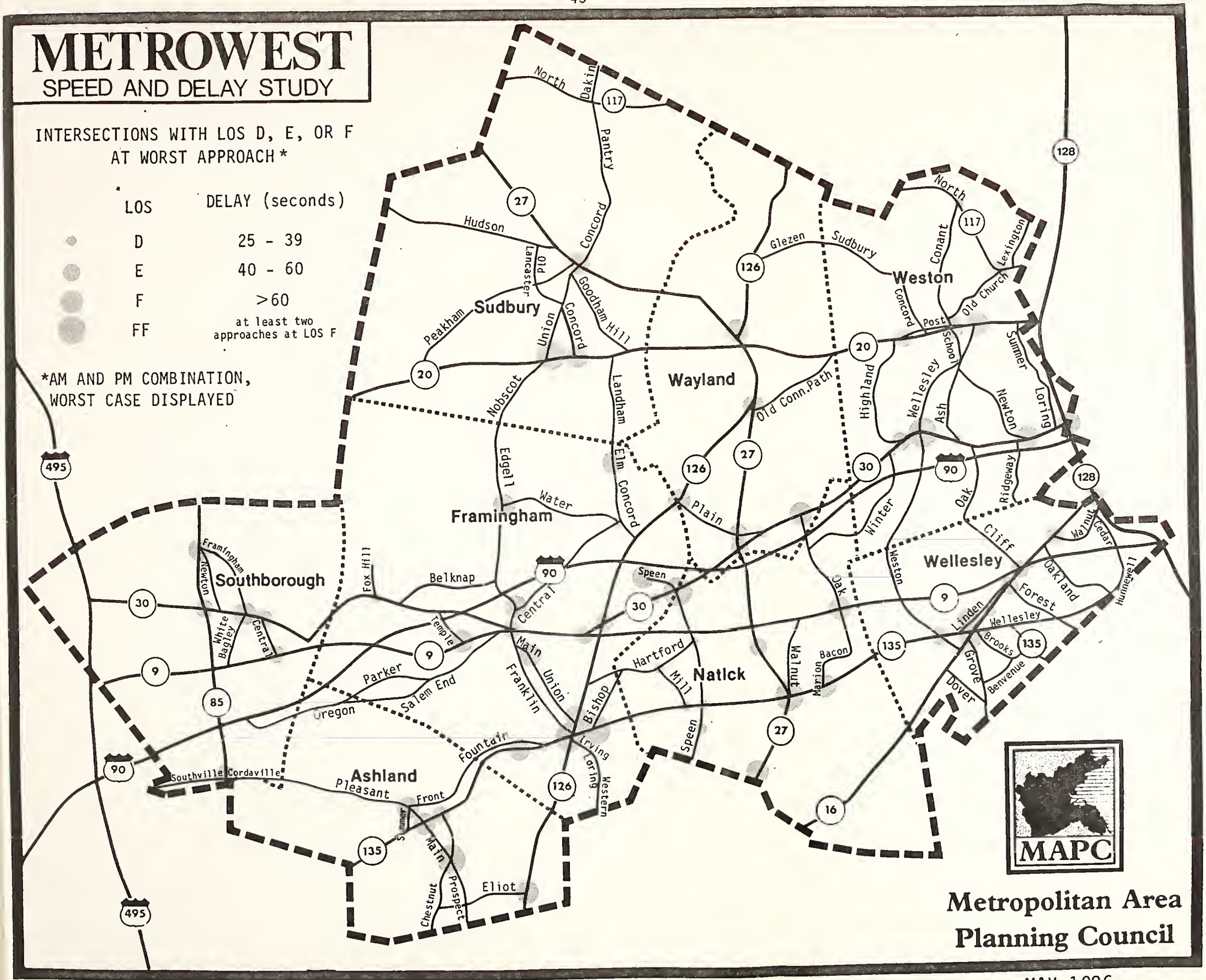
This study identifies the location of traffic problems in the subregion and on the basis of operations; it provides a hierarchy, in terms of level of service, during the peak commuter periods. Problems are a result of intersection deficiencies, and therefore the four major groupings (i.e., at least one approach to an intersection with LOS D, E, or F and 2 or more approaches at LOS F) lend themselves to a ranking of priority. Based on this study, those intersections with two or more approaches at LOS F are of highest priority to improve in order to ease traffic conditions in MetroWest. Therefore the most relief will come by concentrating efforts toward these key intersections.

However, traffic improvements are of most benefit to the public when safety is improved, too. This study only gives locations, but further work including accident analysis is needed. MAPC recommends that the committee select projects within each of the four categories of deficient operations on the basis of safety issues. Project selection by the MDPW is based on an analysis of accidents as well as operations.

In pursuing the locations that are of highest priority based on operations, the Committee should invite the appropriate people from the community i.e., local highway superintendent, town planner, etc., to discuss in detail what work has been done already and what is known about accidents, alternatives for improvements, and the size, timetable and cost for these alternatives. It must be recognized that there may not be a reasonable or cost-effective solution to some intersection problems, but that will be determined with more detailed

OVERLAY - MAP 6





MAP 6

MAY 1986

studies. The MetroWest Growth Management Committee has fashioned a framework for addressing traffic problems in the context of overall growth management policy. The Committee has adopted four policy statements thus far, which are listed below (7).

1) Traffic conditions in the region should not be allowed to deteriorate further. Therefore, MetroWest should encourage local Boards to require traffic mitigation measures as part of the development approval process. Further, as articulated in the signed Memorandum of Agreement among the member towns, the Committee would like to establish a means of regional traffic review and mitigation.

2a) Except where existing hazards must be corrected, highway capacity should not be increased unless the intensity of permitted land use is correspondingly decreased. Increased highway capacity encourages further growth without addressing the longer term implications of that growth.

2b) As a corollary to 2a, any "necessary," (as determined by a town or the MDPW), road improvements should be designed to draw traffic onto the major road network in the region and away from local town and neighborhood roads. These improvements should be evaluated in their full regional context.

3) The intensity of land use allowed in commercial and industrial zones should be reduced along roads which are, or will be, operating at or above capacity. Development should be scaled to the capacity of the infrastructure, taking into account the cumulative impact of small developments.

4) The Committee seeks to maintain the character and integrity of MetroWest's residential neighborhoods. This includes preserving the semi-rural visual appeal resulting from winding roads, stone walls, trees and open spaces.

References

1. Edward Bromage and Daniel Beagan, Route 9 Corridor Planning Study: Short-range Element, Central Transportation Planning Staff, Boston, February 1986.

2. Institute of Transportation Engineers, Special Report 209: Highway Capacity Manual, Transportation Research Board, Washington, D.C., 1985.

3. Travel time data in Weston, Massachusetts collected by Vanasse/Hangen Consulting Engineers and Planners, Boston, from November 1984 to January 1985.

4. Travel time data in Marlborough, Sudbury, and Wayland, Massachusetts collected by Vanasse/Hangen Consulting Enginerrs and Planners, Boston, in June and July of 1985.

5. Rosamond Delori, Memo: Inventory of Traffic Improvements Underway or Identified in MetroWest, MetroWest Planning Office, Natick, Massachusetts, February 20, 1986.

6. Jean Christensen, et al, Route 9 Corridor Planning Study: Land Use Component, Metropolitan Area Planning Council, Boston, February 1986.

7. Virginia Welles, Executive Summary: MetroWest Growth Management Committee Interim Progress Report, MetroWest Planning Office, Natick, Massachusetts, January 15, 1986.

Appendix A - Survey Data

(under separate cover)

Appendix B: Study Route Selection

The routes were selected for study by the following process. As a starting point, MAPC compiled a list of routes found on the "federal-aid system", referring to roads eligible for federal funding, and prioritized them based on a hierarchy beginning with the most mileage in the highest functional class to the least mileage in the lowest functional class. Functional classification is the basis for distribution of various funding categories and is determined by the function a highway performs in relation to the total highway network characterized by such factors as length of trips, operational speeds, and access to abutting property, among others.
These lists were sent to all the MetroWest committee members and local public work directors for comment. They were encouraged to rearrange the order of priority, to add local roads if needed, and to drop roads unnecessary to study.

Appendix C: Data Collection Methodology

By definition, a test run occurs on each occasion that the study route is driven and speed data is collected. For purposes of statistical reliability, it was determined that, ideally, 16 test runs should be made on each route to be studied - four (4) in each direction, during the morning and afternoon peak periods.

Test runs were made during the morning peak period of 7 a.m. to 9 a.m. and the afternoon peak period of 4 p.m. to 6 p.m. Originally the runs were to be made on Tuesdays, Wednesdays and Thursdays only, but midway through the data collection efforts, Monday afternoon and Friday morning were included. The initial limit to the three (3) middle weekdays was due to the strict interpretation of the Institute of Transportation Engineers (ITE) standards, but this standard was loosened when MAPC learned it is common practice for reputable consultants in the area to include Mondays and Fridays when collecting commuter traffic data.

A sample of the field sheet is shown in Figure C-1. Control points are intersections with some type of traffic control device, either a sign or signal. The control points listed in the left-handed column were filled in by MAPC staff before distribution to the coordinators and their volunteer drivers. A map marking the study route was printed on the back of each field sheet, with the location of the control points circled for easy identification. The volunteers recorded the time when passing a control point, and the location, duration, and cause of any delays encountered along the route. Location of delays was designated by control point number. The notation "2-3" means "between control point #2 and #3". A code key is found at the bottom of the field sheet used for recording the cause of delay in abbreviated form.

Two types of travel time information were recorded for each test run. The time to the nearest minute when passing through the middle of an intersection designated as a control point was recorded in order to calculate the speed along a segment of a road. Also, the cause and duration of any delays at an intersection were recorded in seconds in order to determine the level of service (LOS) from each direction of

Figure C-1

Metropolitan Area Planning Council

110 Tremont Street Boston, Massachusetts 02108 (617)-451-2770

Serving 101 Cities & Towns in Metropolitan Boston

Travel Time and Delay Study
Field Sheet (Page 1 of 1)

Date 9/31/85 Trip No. 311 Direction S to N End Mileage 809.2

Route Route 27 Start Mileage 805.8

Town(s) Natick / Wayland Driver C.T. Jones Trip Length 3.4

Control Points	
Location	Time
1 Route 9 (Worcester St)	8:34
2 Pine Street	8:38
3 Route 30 (Commonwealth Rd)	8:41
4 School Street	8:42
5 Route 126 (Old Connecticut Path)	8:44
6 Route 20 (Boston Post Road)	8:47
7	
8	
9	
10	
Time elapsed (min)	13

Stops		
Location	Seconds	Cause
1-2	40	LT
2	8	LT
2-3	15	T
3	35	S
3-4	10	SB
3-4	5	PED
5	26	S
6	20	S
6	2	PED
Total (sec)	161	

SAMPLE

SYMBOLS OF STOP CAUSE: S-Traffic Signals SS-Stop Sign LT-Left Turns
PK-Parked Cars DP-Double Parking T-General Traffic PED-Pedestrians C-Construction
BP-Bus Passengers Loading or Unloading SB-School Bus TR-Trucks O-Other (describe)

Comments (continue of back if needed) Posted speed limit 35 mph from 1-4 and 25mph 4-6

approach to the intersection. Note that the time when passing through the middle of the intersection is used, as opposed to the time of approach to the intersection. When a delay is encountered because of a red light, stop sign, car making a left turn or whatever cause, the stopped time is included in the time it takes to pass between two intersections (or control points) and thus the speed is reduced.

After the study routes were prioritized, MAPC staff drove each route to finalize the data collection procedure and to familiarize themselves with the roads and traffic problems in the study area. This driving was necessary to establish "control points" or benchmarks along a route in order to do speed calculations. Speed and delay data was usually collected at this time, but only if the route was driven during the peak periods.

Each community named a volunteer MetroWest Traffic Study Coordinator to organize data collection efforts in their community. MAPC staff held two informational meetings for the coordinators, at which time instructions on procedure were given and field sheets distributed. The coordinators were given the rearranged lists based on community input and asked to obtain drivers for as many routes as possible, with an emphasis toward their town's order of priority. The instructions called for the volunteers to announce requested data into a tape recorder as they were driving, or to have a passenger record the data onto a coding form.

Appendix D: Validity of Data

Sample size is selected on the basis of an acceptable maximum range of permitted error in accordance with the purpose of the study. In this case, the purpose is to evaluate traffic operations, having a suggested permitted error of no more than ± 4.0 mph (2). This means the maximum permissible departure from the average speed is 4 mph. The greater the range of speeds, the more runs are needed. Keep in mind that the observed average (mean) speed for a line is an estimate which would be constantly revised every time an observation is made and averaged in.

For example, a route is driven four times in the eastbound direction during the morning peak period. The observed speeds are 17, 19, 21, and 22 miles per hour (mph). The range, or difference between the lowest and highest speeds is 5 mph. Given this range, four runs have a specified permitted error of 2 mph (2). The observed speeds in the reverse direction were 12, 20, 20, and 22 mph. With a range of 10 mph and a permitted error of + 4 mph, the data would be valid for the purpose of the study. It is possible for the range to increase as the number of runs increases.

Validity must be determined for each route in each direction in both the AM and PM peak periods. At the outset of the survey, we asked volunteers for four runs on each road segment to insure statistical validity. However, cases where 2 runs were made with an observed range in travel speed of 5.0 mph yield a permitted error of 4.0 mph, which is adequate for our purposes.

Appendix E: Level of Service (LOS) Criteria

The criteria used for level of service (LOS) are from the 1985 Highway Capacity Manual (2). LOS categories are designated by the letters A through F with A denoting the best conditions and F the worst. A set of LOS criteria are defined for both roadway segments based on average speeds and for intersections based on average duration of stopped time at the intersection.

LOS criteria for streets vary in accordance with the design. The criteria used in this analysis are for arterial class II (2), which is intermediate between an urban and suburban design. While many of the listed characteristics for class II do not match those of the roads studied (i.e. 4-8 signalized intersections per mile), the more significant ones do. Such criteria as a posted speed limit of 30-40 mph, and free flow speed of 30-35 seemed reasonable guidelines. A roadway with an average traveling speed above 30 mph is judged to be LOS A; declining service levels are assigned to decreasing ranges of speeds, with speeds less than 10 mph marking the cutoff for LOS F.

Level of Service is defined in terms of delay for both signalized and unsignalized intersections (2). Delay is a measure of driver discomfort, frustration, fuel consumption, and lost travel time.

Appendix F: Use of Volunteers

The idea behind using volunteer drivers was for commuters to document their daily commutes. Some towns met with more success using this approach than others. The towns of Framingham and Sudbury used town employees. Wellesley and Weston relied heavily on members of the League of Women Voters. The remaining communities aimed at the general citizenry with limited success. Six volunteers came forth as a result of their interest being sparked by local newspaper coverage in the Middlesex News, the Wayland/Weston Town Crier, and the Wellesley Townsman.

The goal of increasing community awareness through participation was met through the volunteer approach. Drivers and coordinators expressed their appreciation of the effort required for traffic studies after having the experience of collecting data for this one. While a lot of staff time was spent on "coordinating the coordinators" and sifting through data which was collected by many individuals, 72% of the miles were driven by volunteers.

Many volunteer drivers dropped out because they had a difficult time collecting the requested data as they drove. This is an awkward task - requiring one to keep track of time on a clock and to operate a tape recorder (unless a passenger records by hand) while driving in heavily congested traffic. While staff members found it initially difficult, it became "second nature" with practice. Some of the volunteers found it too stressful to continue. Even more confounding was the problem unforeseen by staff that, after the first week of data collection efforts, Eastern Standard Time resumed causing most surveying to occur after dark in the evening peak period (4 to 6 p.m.).

Appendix G
MetroWest Speed and Delay Study
Coordinators and Drivers

Ashland	Coordinator: Rocco Annesi Driver: Ed Bates, Mary DeSalvo
Framingham	Coordinator: Frederick Taintor Drivers: James Bosworth, Joseph Champaigne, Arthur Noonan, Maggie Raymond (volunteer), Frederick Taintor, James Wakeman, Walter Yusikones
Natick	Coordinator: Sebastian Grupposo Drivers: Sue Berggren, Faith Casler, Kathleen Curry, Susan Lebrun, Jim Nickerson, Ann Rollins, William Rollins
Southborough	Coordinator: Charles Gaffney Driver: Charles Gaffney
Sudbury	Coordinator: James Merloni Drivers: Dennis Bourque, David Flaherty, William Slavin
Wayland	Coordinator: Sue Damour Drivers: John Antes, Marty Gordon, David Lang, Athlene Nixon, Robert Paine, Steve Rostler
Wellesley	Coordinator: Gail Oliva Drivers: Richard Brown, Barbara Butterfield, Dorothy Ellis, Joyce Kingery, Edward Oliva, Katherine Nagle, Anita Thomson
Weston	Coordinator: Robert Mosher Drivers: Jane Brigham, Thea Gray, Valerie Kirshy, Susan Kuhr, Francine Lee, Betsy Nichols Jean Thurston, Inge Uhlir, Joan Wilson, Marillyn Zacharis

Appendix H

Highway Segments for which Valid Data was Collected in One Direction Only which have Level of Service (LOS) D, E, or F

Roadway	From	To	Town	AM Peak Period	PM Peak Period
Main Street	Myrtle St.	Rt. 135	Ashland	X	X
Summer Street	Main St.	Rt. 135	Ashland		X
Bishop Street	Arthur St.	Rt. 135	Framingham	X	
Foxhill Road	Tallyho Lane	Rt. 30	Framingham	X	
Franklin Street	Main St.	Wayte Ave.	Framingham		X
Irving Street	Rt. 135	Loring Dr.	Framingham	X	
Old Salem End Road	Oregon St.	Parker St.	Framingham	X	X
Old Salem End Road	Temple St.	Rt. 9	Framingham	X	X
Rte. 126	Winthrop St.	Rt. 135	Framingham	X	
Temple Street	Rt. 30	Rt. 9	Framingham	X	
Marion Street	Bacon St.	Rt. 135	Natick	X	